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Transmitted herewith for filing is an original (nonprovisional)
patent application of:

Inventor(s): Fan Kong

Entitled: Method and Apparatus for Scalable Handling of Non-
Tree Structures in Parser Tree Reconstruction

Enclosed are the following papers as required for a filing date
under 37 C.F.R. §1.53(b):

 Sheets Microfiche Appendix;
46 Pages Description;
9 Pages Claims;
1 Page Abstract; and
20 Drawing Sheets(Informal).

Other papers enclosed include:

 X Return Receipt Postcard
 X Check for \$ 1298.00
2 Pages of Combined Declaration For Patent
Application and Power of Attorney

New Patent Application Transmittal Letter
Attorney Docket No. CSC02337

Page 2

Pages of Statement Claiming Small Entity
_____ Status (37 CFR 1.9(f) and 1.27(b) -- Small
Business Concern)
X Recordation Form Cover Sheet
_____ 1 Page(s) of Assignment of the invention to
Cisco Systems, Inc.

Fee Calculation					
Claims	Number Filed	Basic Fee Allowance	Number Extra	Rate	Basic Fee
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Respectfully submitted,



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Method and Apparatus for Scalable Handling of Non-Tree
Structures In Parser Tree Reconstruction

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Fan Kong

BACKGROUND OF THE INVENTION

10 Field of the Invention

The present invention relates generally to parsing, and more particularly to determining a reverse path through a parse tree using information in a system configuration database.

15

Description of Related Art

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Typically, when an operating system command is used to configure a router, a parser processes the command using a binary parse tree. The router is configured as specified in the operating system command based on information derived from the parsing. The data used to configure the router is stored in a system configuration database.

25

Frequently, it is necessary to access the information in the system configuration database and reconstruct the command or commands that were used to configure the router. This can be a formidable problem that requires significant time to execute.

30

As a demonstration of the problem, consider binary parse tree 100 of Figure 1. Binary parse tree 100 typically was used in a router's operating system in processing configuration commands. At each of nodes 101 to 119, there can be zero, one, or two branches. The path that terminates at each of the end nodes of binary parse tree 100 represents a

35

configuration state for the router. The particular configuration state obtained when the configuration command represented by binary parse tree 100 is executed is stored in the system configuration database.

To regenerate the original configuration command, the information in the system configuration database was used and each route through binary parse tree 100 was tested for validity. For simple binary parse tree 100, this could be done relatively quickly. However, the number of paths grows exponentially/geometrically with the number of tree layers and nodes. Consequently, the execution time required increased significantly as the commands became more complex. Unfortunately, given the system constraints in router hardware and the complicated configuration commands, improvements in the execution time would appear to require significant advances in router hardware performance.

SUMMARY OF THE INVENTION

According to the principles of this invention, a novel linear node eliminates the geometric progression associated with prior art binary nodes, when the linear node is utilized in parse trees. The linear characteristics of the novel linear node are particularly advantageous in reconstructing a configuration command.

A method for processing a command having at least one command element that can have a plurality of values represents the at least one command element by a linear node in a parse tree. The linear node includes a begin option node having a single entrance; one or more next option nodes coupled to the begin option node; and an

end option node coupled to the begin option node. The end option node has a single exit.

In one embodiment, the method includes connecting a plurality of branches to the begin option node. Each
5 branch in the plurality of branches represents a different value of the at least one command element. Also, each branch is associated with a different next option node.

A network device, according to the principles of
10 this invention, includes a processor; and a memory coupled to the processor. At least one linear node having a single entry and a single exit is stored in the memory. The linear node includes a begin option node connected to the single entry; a next option node
15 coupled to the begin option node; and an end option node coupled to the begin option node and connected to the single exit. The linear node is included in a parse tree in the memory upon the processor executing a process to parse a command.

In one embodiment, the begin option node stored in
20 the memory is coupled to a plurality of branches of the at least one linear node. Each branch in the plurality of branches represents a different value of at least one command element of a command for the network
25 device. Also, each branch in the plurality of branches is associated with a different next option node.

According to the principles of this invention, a method for regenerating a command includes storing a
linear command regeneration template including a linear
30 node template in a memory; and reconstructing the command using the linear command regeneration template and data from a database.

The storing a linear command regeneration template further includes storing a begin option node template,

a next option node template and an end option node template in the linear node template.

Reconstructing the command using the linear command regeneration template and data from a database includes filtering the linear command regeneration template to locate the linear node template. The filtering includes scanning the linear command regeneration template to find a begin option node template, and obtaining an identification of the begin option node template. Next, the linear command regeneration template is scanned to find an end option node template including the identification. The begin option node template and the end option node template delimit a linear node template.

The linear node template is passed from the linear command regeneration template to an evaluate branches process, which in turn evaluates at least one branch in the linear node template from the linear command regeneration template.

Evaluating at least one branch in the linear node from the linear command regeneration template includes finding a branch in the linear node template, and validating the branch using the data from the database.

In another embodiment, a network device includes a processor; and a memory coupled to the processor. The memory stores a method for regenerating a command wherein upon execution of the method by the processor, the method comprises:

storing a linear command regeneration template including a linear node template in the memory; and

reconstructing the command using the linear command regeneration template and data from a database.

In yet another embodiment, a structure for regenerating a command includes means for storing a linear command regeneration template including a linear node template in a memory; and means for reconstructing
5 the command using the linear command regeneration template and data from a database.

The means for storing a linear command regeneration template further includes means for storing a begin option node template in the linear node
10 template; means for storing a next option node template in the linear node template; and means for storing an end option node template in the linear node template.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Figure 1 is a prior art binary parse tree.

Figure 2A is a diagram of a network device that includes a memory storing a linear parse tree of this invention, and a linear command regeneration template of this invention.

20 Figure 2B is an alternative diagram of the network device of Figure 2A wherein the linear parse tree of this invention is a part of a binary parse tree.

Figure 3 is a more detailed diagram of the linear node structure of this invention.

25 Figure 4A is an illustration of a prior art network device configuration command.

Figure 4B is a prior art binary parse tree for the network device configuration command of Figure 4A.

30 Figure 4C is an illustration of the prior art binary node path templates stored for regeneration of the network device configuration command of Figure 4A.

Figure 4D is a detailed diagram of the linear parse tree of this invention for the network device configuration command of Figure 4A.

Figure 4E is one embodiment of a process flow diagram of a linear command regeneration method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

5 Figure 5 is one embodiment of a process flow diagram of a begin option node method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

10 Figure 6 is one embodiment of a process flow diagram of a next option node method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

15 Figure 7 is one embodiment of a process flow diagram of an end option node method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

20 Figure 8 is one embodiment of a process flow diagram of a begin option node template generation method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

Figure 9 is one embodiment of a process flow diagram of a next option node template generation method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

25 Figure 10 is one embodiment of a process flow diagram of an end option node template generation method of this invention that is stored in a memory for execution by the processor of Figures 2A and 2B.

30 Figure 11 is a process flow diagram of one embodiment of a filter option method according to the principles of this invention.

Figure 12 is a process flow diagram of one embodiment of a pick option path method according to the principles of this invention.

Figure 13 is a diagram of the linear node structure of this invention for a first embodiment of an if control structure.

Figure 14 is a diagram of the linear node structure of this invention for a second embodiment of an if control structure.

Figure 15 is a process flow diagram of one embodiment of a then node method according to the principles of this invention.

Figure 16 is a process flow diagram of one embodiment of an else node method according to the principles of this invention.

In the Figures and Description, elements with the same reference numeral are the same element.

DETAILED DESCRIPTION

According to the principles of this invention, a novel linear parse tree 200 is utilized. Linear parse tree 200 is a structure in a memory 220 (Fig. 2A). Linear parse tree 200 provides the same functionality, as the prior art binary parse tree, for parsing a configuration command for a network device 230, such as a router. While the operating system and configuration commands for a router are considered in this embodiment, the invention is not limited to such a configuration. The linear nodes and linear parse tree of this invention can be incorporated in any configuration or system that utilized the prior art binary parse tree.

Since linear parse tree 200 changes the geometric progression of the prior art binary parse tree to a linear progression, reconstructing a system configuration command from data in a system configuration database 260 is much faster than the prior art method. For example, to process twenty-seven

successive option branches, each having two options,
using the prior art binary parse tree required 2^{27} units
of processing. Processing the same twenty-seven
successive options using this invention requires
5 $2 * 27$, or 54, units of processing (plus overhead).
Consequently, while providing the same functionality as
the prior art, linear parse tree 200 of this invention
significantly enhances performance. Moreover, the
linear progression associated with linear parse
10 tree 200 permits easy scaling of commands without
incurring a geometric increase in processing time.

Linear parse tree 200 includes a plurality of
linear nodes 201 to 203. Each of linear nodes 201
to 203 has a single entry and a single exit. The use
15 of three linear nodes is illustrative only and is not
intended to limit the invention to any particular
number. In view of the disclosure, any number of
linear nodes can be utilized.

Using only the linear nodes of this invention
20 results in linear parse tree 200. Alternatively, if
desired, a parse tree 250 (Fig. 2B) can be created in
memory 220 that includes a plurality of binary
nodes 252, 253, and 254 and one or more linear nodes of
this invention, e.g., linear nodes 201 to 203 in
25 Figure 2B. It is important to understand that linear
nodes 201 to 203 are not simply binary nodes that are
allowed one option path. In contrast, as explained
more completely below, linear nodes 201 to 203
(Figs. 2A and 2B) permit the same functionality that
30 was achieved with the prior art binary parse trees
without incurring the geometric increase in processing
time as the complexity of the parse tree increases.

Each of linear nodes 201 to 203 is constructed
using a set of versatile branching tokens that include
35 a begin option token 301 (Fig. 3), sometimes called

begin option node 301, and an end option token 302,
sometimes called end option node 302. Herein, only
linear node 201 is considered in detail. In view of
this description, those of skill can construct other
5 linear nodes that implement the desired functionality.

As illustrated in Figure 3, in linear node 201,
begin option node 301 has a direct link to end option
node 302. Begin option node 301 has a single entry,
and also includes a list of links 310 with each entry
10 in the list being a link to one of parallel
branches 303a to 303n.

Each of branches 303a to 303n has a similar
structure. In one embodiment, each of boxes 304a
to 304n represents one possible value of a command
15 element of the configuration command. If an input
value of the command element in the configuration
command matches the value represented by the box,
processing transfers to a next option node that in turn
branches back to begin option node 301. The matched
20 branch is added to matched link list 311, sometimes
called matched branch list 311.

The action taken by begin option node 301 upon
processing being returned from a next option node
depends on the configuration of begin option node 301.
25 Begin option node 301 can be configured so that (i)
when a single match is obtained, processing is
transferred to end option node 302; (ii) when any
combination of matches is obtained, processing is
transferred to end option node 302; (iii) when all
30 branches match processing is transferred to end option
node 303; or (iv) when a count of the number of pushes
of the branch equals the array count of a generic array
processing is transferred to end option node 303.

In one embodiment, one or more of boxes 304a
35 to 304n can be another linear node, i.e., a linear node

can be included within a linear node, i.e., there is a pointer to a special data structure of possible paths in option. In particular, the linear nodes of this invention can be recursive. In this embodiment, the
5 inner linear node would be processed as described herein, and then processing would revert back to the outer linear node. The important aspect is that the linear characteristics are maintained.

To further demonstrate the principles and
10 advantages of this invention, consider configuration command **TEST** of Figure 4A. In this embodiment, a first command element 421 can have values "A" or "B" and the value specified in the configuration command is assigned to argument ten. A second command element 422
15 can be either a number, or a non-number string. If the value of the second command element is a number, the value is assigned to argument one. If the value of the second command element is a non-number string, the value is assigned to argument two.

20 The configuration command of Figure 4A is input to network device 230 using an input device, or alternatively the configuration command could be supplied over via a network interface. The process of entering the configuration command is well known.

25 In response to entry of the configuration command the network device operating system, or another process executing on network device 230 processes the configuration command. Herein, when it is stated that the network device or an operation in a method takes a
30 particular action or results in a particular action, those of skill in the art will understand that one or more instructions have been executed by the processor in the device and as a result the stated operations are performed.

Figure 4B is an example of a prior art binary parse tree 400 for configuration command **TEST** of Figure 4A. Figure 4C is the prior art sequence of paths for binary parse tree 400 that were used to reconstruct the command using information in system configuration database 260. The creation of the binary parse tree and the sequence of paths is known to those of skill in the art and so is not described further.

Each of the paths in Figure 4C was evaluated to reconstruct command **TEST** using data in system configuration database 260. In this simple example, only four paths were evaluated. However, a more complex configuration command could have, for example, as many as 5,760 separate paths that have to be evaluated to reconstruct the complex configuration command.

Figure 4D is a linear parse tree 450, using linear nodes 451, 452 of this invention. Linear parse tree 450 is a structure in a memory (not shown). Linear parse tree 450 starts with begin option node 401 that has a single entry, and includes two branches 403a and 403b, one for each of the possible values of first command element 421. In each of branches 403a and 403b, if the test for the value is true, argument ten is set to the value and processing transfers to the next node, one of next option nodes 405a and 405b, respectively, in the branch. The next option node returns processing to begin option node 401. Thus, each next option node 405a and 405b is coupled to begin option node 401.

In the example of Figure 4A, the first command element can have either the value AA, or the value BB. Consequently, parameter flags in begin option node 401 is set to single branch.

When a match is detected and processing passes through a next option node back to begin option node 401, begin option node 401 transfers to end option node 402, which performs any necessary clean up. End option node 402, which has only a single exit, transfers to a second begin option node 411.

In this example, begin option node 411 also includes two branches 413a and 413b, one for each of the possible values of second command element 422. In branch 413a, if the test for a number is true, argument one is set to the number and processing transfers to next option node 415a. Next option node 415a returns processing to begin option node 411. In branch 413b, if the test for a string is true, argument two in branch 413b is set to the string and processing transfers to next option node 415b. Next option node 415b returns to begin option node 411. If neither branch is true, an error message to the user is generated.

In the example configuration command of Figure 4A, second command element 421 can be either a number or the non-number string. Consequently, parameter flags in begin option node 411 also is set to single branch. Consequently, when a match is detected and processing passes through a next option node back to begin option node 411, begin option node 411 transfers to end option node 412, which performs any necessary clean up. End option node 412 transfers to an end of line EOL that writes the parsed configuration command to system configuration database 260. The configuration of the system using the data from the parsed configuration command is the same as that in the prior art and so is known to those of skill in the art.

As a part of parsing a configuration command, a linear command regeneration template 270 (Fig. 2A),

i.e., one line, is written to a file 271 in memory 220. Linear command regeneration template 270 subsequently is used to regenerate the configuration command using the data in system configuration database 260, as described more completely below. The general format for command regeneration template 270 is given in TABLE 2.

TABLE 2

Command {B} P1 {N} P2 {N} . . . {N} {E} . .
{B} P1 {N} P2 {N} . . . {N} {E}

Each command element is represented by a linear node that has a begin option node template {B} and an end option node template {E}, i.e., the linear node is delimited by the begin option node template {B} and the end option node template {E}. The various paths, sometimes called branches or options, from a begin option node {B} are represented by P1, P2, . . . , and are followed by a next option node template {N}. Paths P1, P2, . . . , are generic representations for the first and second paths of a linear node and are not intended to indicate that, for example, the first path of every linear node is the same. Irrespective of the number of command elements and the number of branches associated with a command element, a single linear line is written to file 271.

To better understand the linear command regeneration template consider configuration command **TEST**, as illustrated in Figure 4A. For configuration command **TEST**, linear command regeneration template 270 that is written to file 271 is presented in TABLE 3.

TABLE 3

5 TEST {B, 2, S, ID1, 0} AA, <10, AA> {N, ID1}
BB, <10, BB> {N, ID1} {E, ID1}
(B, 2, S, ID2, 0} <n>, <1,<n>> {N, ID2}
string, <2, string> {N, ID2} {E, ID2}

10 TABLE 4 presents a comparison of the general
format of TABLE 2 with the specific implementation of
TABLE 3 for the first command element of configuration
command **TEST**. TABLE 4 assists in relating the general
format to both the configuration command and linear
parse tree 450.

15

TABLE 4

General Format for Linear Node	Specific Implementation
{B}	{B, 2, S, ID1, 0}
P1	AA <10, AA>
{N}	{N, ID1}
P2	BB <10, BB>
{N}	{N, ID1}
{E}	{E, ID1}

20 In the embodiment of Figure 4D, the begin option
node template for begin option node 401 is written with
a "B" to identify the node as a begin option node of
linear node 451 for first command element 420.
Following the "B," is a number that represents the
number of branches associated with begin option
25 node 401, which is two. Next is parameter flags, which
is set to single in this example. Following parameter
flags is an identifier for linear node 451, which is

explained more completely below. Finally, a bypass
flag is either set to true or false to indicate that
linear node 451 includes a bypass. Thus, in this
implementation, in general, a begin option node
5 template is written in linear command regeneration
template as:

{B, No. of branches, flags, Linear Node ID, Bypass}

10 Branch P1 first identifies the value of the
command element for which the branch tests, e.g., "AA"
and the argument that is set to value "AA" if the test
is true. The format for branch P2 is similar. Next
option node templates {N} are written with the linear
15 node identifier as are end option node templates {E}.

Figure 4E illustrates one embodiment of a
configuration command regeneration process 460 that is
used to reconstruct a configuration command using the
command reconfiguration template of this invention. (A
20 more detailed embodiment is described below with
respect to Figures 11 and 12.) To illustrate
process 460 assume that command **TEST**, as described
above, was

25 TEST AA abcd.

Thus, in system configuration database 260,
argument ten is AA, argument one is undefined, and
argument two is string abcd. Linear command
30 regeneration template 270 is given in TABLE 3.

Find node operation 461 scans linear command
regeneration template 270 to find a linear node. As
explained above, linear node 451 is delimited by the
begin option node template with identification ID1 and

the end option node template with identification ID1.
(See TABLE 3.) Thus, find node operation 461 finds:

5 {B, 2, S, ID1, 0} AA, <10, AA> {N, ID1}
BB, <10, BB> {N, ID1} {E, ID1}

This string is cut from template 270 and passed to find
branch operation 464 through linear node found check
operation 462.

10 In find branch operation 464, the first path,
e.g.,

AA, <10, AA>,

15 is found between the right brace of the begin option
node template and the left brace of the first next
option template with identification ID1, and becomes
the current branch. Since a branch was found, branch
found check operation 465 transfers to include linear
20 node check operation 466.

In linear node check operation 466, the current
branch is scanned to determine whether the branch
includes a begin option node template. If a begin
option node template is found in the current branch,
25 check operation 466 returns to find node operation 461
to locate the linear node within the current branch.
Otherwise, check operation 466 transfers to validate
branch operation 467.

In validate branch operation 467, the data in
30 argument ten in system configuration database 260 is
compared with the value assigned to argument ten by the
current branch. In this example, the value for both is
AA and so the current branch is valid. Consequently,
valid check operation 468 transfers to append string
35 operation 469.

In append string operation 469, the evaluated current branch is appended to a configuration command string, which after operation 469 is:

5 TEST AA.

Upon completion of append string operation 469, single branch check operation 470 determines whether parameter flags in the current begin option node
10 template is set to single. In this example, parameter flags is single, and so branch check operation 470 transfers to find node operation 461. If parameter flags is other than single, check operation 470 transfers to find branch operation 464, and
15 operations 464 to 470 are repeated for the next branch as appropriate.

Upon returning to operation 461, find node operation 461 scans the remainder of linear command regeneration template 270 to find another linear node.
20 As explained above, linear node 452 is delimited by the begin option node template with identification ID2 and the end option node template with identification ID2. (See TABLE 3.) Thus, find node operation 461 finds:

25 (B, 2, S, ID2, 0} <n>, <1,<n>> {N, ID2}
string, <2, string> {N, ID2} {E, ID2}

This string is cut from template 270 and passed to find branch operation 464 through linear node found check
30 operation 462.

In find branch operation 464, the first path,
e.g.,

<n>, <1,<n>>,
35

is found between the right brace of the begin option
node template and the left brace of the first next
option template with identification ID2, and becomes
the current branch. Since a branch was found, branch
5 found check operation 465 transfers to include linear
node check operation 466.

In linear node check operation 466, the current
branch is scanned to determine whether the branch
includes a begin option node template. Check
10 operation 466 transfers to validate branch
operation 467.

In validate branch operation 467, the data in
argument one in system configuration database 260 is
compared with the value assigned to argument one by the
15 current branch. In this example, the value for
argument one in the database 260 is invalid and so this
branch is not valid. Consequently, valid check
operation 468 transfers to find branch operation 464.

In find branch operation 464, the second path,
20 e.g.,

string, <2, string>,

is found between the right brace of the first next
25 option node template and the left brace of the second
next option template with identification ID2, and
becomes the current branch. Since a branch was found,
branch found check operation 465 transfers to include
linear node check operation 466.

In linear node check operation 466, the current
branch is scanned to determine whether the branch
includes a begin option node template. Check
30 operation 466 transfers to validate branch
operation 467.

In validate branch operation 467, the data in argument two in system configuration database 260 is compared with the value assigned to argument two by the current branch. In this example, the value for
5 argument two in the current branch is a string. Consequently, valid check operation 468 transfers to append string operation 469.

In append string operation 469, the evaluated current branch is appended to a configuration command
10 string, which after operation 469 is:

TEST AA abcd.

Upon completion of append string operation 469,
15 single branch check operation 470 determines whether parameter flags in the current begin option node template is set to single. In this example, parameter flags is single, and so branch check operation 470 transfers to find node operation 461.

20 Find node operation 461 fails to find another linear node. Consequently, node check operation 462 transfers to exit operation 463 that cleans up memory, and returns the regenerated configuration command.

In summary, the linear command regeneration
25 process 460 of this invention includes two primary operations. First, a linear command regeneration template is scanned to find a linear node in locate linear node operation 470. (Fig. 4E.) When a linear node is found, each branch in the linear command
30 regeneration template for that linear node is evaluated if appropriate, and if valid, the evaluated branch is appended to a regenerated command string in valuate branches operation 471.

The linear nodes of this invention are implemented
35 within a conventional parser and place data on a

parsing stack that is utilized as in the prior art. Consequently, herein only the features required to add the linear nodes to the conventional parser are described. The particular implementation of the parser
5 that utilizes the linear nodes of this invention is not essential to this invention. Hence, one embodiment of each of begin option node, next option node and end option node are considered in further detail.

TABLE 5 is pseudo code for begin option node
10 handling logic during parsing of user inputs

TABLE 5

```

Beginoption {
15   Get the option ID, and check if this is the first
      encounter by trying to locate it on the
      option stack.
      If new
          create item on option stack
20   push endoption node on parsing stack,
          increment end count
          iterate all branches and push all to parsing
          stack in reverse order
      else
25   if "generic array"
          push endoption node
          increment end count
          increment the global argument increment
          offset
30   if match count still smaller than total
          array element count
          push the branch
      else if "single"
          push endoption node on parsing stack
35   exit function

```

```

        else if "combo"
            push endoption node
            increment end count
            push all unmatched branches' start nodes
5              in reverse order
        else (i.e. "all")
            if all branches have matched
                push endoption node
                increment end count
10            else
                push all unmatched branches' start
                    nodes in reverse order
        }

```

15 Figure 5 is a process flow diagram 500 for the
embodiment of a begin option node presented in TABLE 5.
Upon entry to begin option node method 500, get
identification operation 510 obtains an option
identification that uniquely identifies the offset
20 position of the end option node in the parse tree.
Operation 510 transfers to new check operation 520.

 In new check operation 520, an option stack is
accessed to determine whether the option identification
obtained in operation 510 is on the option stack. If
25 the option identification is on the option stack, the
begin option node is not new. Conversely, if the
option identification is not on the stack, the begin
option node is new. If the begin option node is new,
check operation 520 transfers to create item
30 operation 521, and otherwise to array check
operation 570.

 In create item operation 521, a matched branch
list 311 (Fig. 3) in the begin option node is set to
null. A next pointer for the begin option node is set
35 equal to a pointer to the top of the option stack, and

flags associated with a bypass, e.g., has a bypass and ignore bypass, are set to false. Operation 521 transfers to push end option operation 522.

Push end option operation 522 places an end option
5 node on the parsing stack while increment count
operation 523 increments an end counter. Push branches
operation 524 iterates through the branches of the new
begin option node, starting with the last branch, and
pushes each branch on the parsing stack. Specifically,
10 this pushes the first node of each branch on the
parsing stack. A pointer is maintained to the next
branch associated with the begin option node. Finally,
operation 524 goes to exit 525, which terminates
processing method 500 at this time.

15 The parser pops the first node of each branch in
turn off the parsing stack and tests to determine
whether the branch condition is true. In the normal
parsing fashion, the parser tries to parse the nodes in
a branch successively. If the parse chain for a branch
20 is parsed successfully, the last token in the branch
that is processed is next option node method 600
(Fig. 6). TABLE 6 is pseudo code for one embodiment of
next option node method 600.

25 TABLE 6

```
Nextoption {
    get the option ID (can't find => error)
    add the current branch ID into the matched branch
30     list of current option ID
    push the corresponding beginoption node into the
        parsing stack
}
```

In method 600 (Fig. 6), get ID operation 601
35 obtains the option ID for the begin option node

containing the matched branch. This makes the option ID the current item on the option stack, i.e., the current option ID. Get ID operation 601 transfers to ID found check operation 602.

5 If the option ID cannot be found, check operation 602 transfers to error operation 603, which in turn generates an error message. If the option ID is found, found check operation 602 transfers processing to update match list operation 604.

10 In update match list operation 604, the branch ID for the matched branch is written to matched branch list 311 for the current option ID, and processing transfers to push begin option operation 605. In push begin option operation 605, the begin option node for
15 the current option ID is pushed on the parsing stack, and method 600 is exited.

 Upon return to method 500, get identification operation 510 obtains an option identification that uniquely identifies the offset position of the end
20 option node in the parse tree. Operation 510 transfers to new check operation 520.

 In new check operation 520, the option stack is accessed to determine whether the option identification is on the option stack. Since the option
25 identification is on the option stack, check operation 520 transfers to array check operation 570.

 At this point, the actions taken depends upon the value of parameter flags for the begin option node. Each value of parameter flags and the resulting action
30 is considered in turn. Array check operation 570 determines whether parameter flags is set to generic array. If parameter flags is set to generic array, processing transfers to push end option node operation 571 and otherwise to single check
35 operation 530.

Push end option node operation 571 pushes the end option node on the parsing stack and transfers to update increment offset operation 572. In increment offset operation 572, a global argument increment
5 offset is incremented. The combination of the current option ID and the global argument increment offset are used to address the option stack as a random access memory. Upon completion, operation 572 transfers to match count check operation 573.

10 If the count of matched branches is smaller than the total array element count, match count check operation 573 transfers to push branch operation 574 and otherwise to exit 575. In push branch operation 574, the branch is pushed on the parsing
15 stack and operation 574 transfers to exit 575.

Returning to Figure 5 for begin option node 500, and assuming that parameter flags is set to single, processing transfers through new check operation 520, and array check operation 570 to single check
20 operation 530. Since parameter flags is set to single, check operation 530 transfers to push end operation 531.

Push end node operation 531 pushes the end option node on the parsing stack and method 500 exits through
25 exit 532.

When the parser pops the end option node off the parsing stack, end option node method 700 (Fig. 7) is executed. TABLE 7 is pseudo code for one embodiment of end option node method 700.

30

TABLE 7

```
Endoption {
  get the option ID (can't find => error)
  35 decrement the end count
```

```
If "generic array"
    Reset global argument increment offset to zero
If end count > 0
    push the next parsing node to parsing stack
5    set ignore bypass flag
else
    if (bypass) and not (ignore bypass)
    push the next parsing node to parsing stack
    endif
10    clean up option stack (pop and free memory)
}
```

In method 700, get ID operation 701 obtains the option ID for the begin option node containing the matched branch. This makes the option ID the current item on the option stack, i.e., the current option ID. Get ID operation 701 transfers to ID found check operation 702.

If the option ID cannot be found, check operation 702 transfers to error operation 703, which in turn generates an error message. If the option ID is found, found check operation 702 transfers processing to update end count operation 704.

In update end count operation 704, the end count is decremented and processing transfers to array check operation 715. If parameter flags is set to generic array, check operation transfers to update increment offset operation 716, and otherwise to end count check operation 705. Update increment offset operation 716 resets the global argument increment offset to zero and transfers to end count check operation 705. If the end count is greater than zero, end count check operation 705 transfers to push node operation 706.

Push node operation 706 pushes the next parsing node to the parsing stack and transfers to set flag

operation 707. Set flag operation 707 sets the ignore bypass flag for the begin option node with the current ID, and exits end option node method 700 via exit 708.

If the end count is zero, end count check
5 operation 705 transfers to bypass check operation 709. Bypass check operation 709 determines whether the bypass flag is true and the ignore bypass flag is false. If the bypass flag is true and the ignore bypass flag is false, check operation 709 transfers to
10 push node operation 710 and otherwise to clean-up operation 711.

Push node operation 710 pushes the next parsing node to the parsing stack and transfers to clean-up operation 711. Clean-up operation 711 cleans up the
15 option stack, frees memory, and exits end option node method 700 via exit 712.

Returning to Figure 5 for begin option node 500, and assuming that parameter flags is set to combo, processing transfers through new check operation 520,
20 array check operation 570, and single check operation 530, to combo check operation 540. Since parameter flags is set to combo, check operation 540 transfers to push end operation 541.

Push end option operation 541 places an end option
25 node on the parsing stack while increment count operation 542 increments the end counter. Push branches 543 iterates through the branches of the begin option node, starting with the last branch, and pushes all unmatched branch, i.e., all branches not in matched
30 branch list 311, on the parsing stack. Finally, operation 543 goes to exit 544, which terminates processing method 500 at this time.

Returning to Figure 5 for begin option node 500, and assuming that parameter flags is set to all,
35 processing transfers through new check operation 520,

array check operation 570, single check operation 530,
and combo check operation 540 to all match check
operation 550. Since parameter flags is set to all,
all match check operation 550 determines whether all
5 branches have been matched. (Note that all the
branches are pushed just once. Therefore, each branch
is popped and processed just once.) If all branches
have been matched, check operation 550 transfers to
push end option node operation 551, and otherwise to
10 push branches operation 560.

Push end option node operation 551 places an end
option node on the parsing stack while increment count
operation 552 increments the end counter. Finally,
operation 552 goes to exit 553, which terminates
15 processing method 500 at this time.

Push branches 560 iterates through the branches of
the begin option node and starting with the last branch
pushes all unmatched branch, i.e., all branches not in
matched branch list 311, on the parsing stack.
20 Processing exits through exit 561.

In addition, to parsing the configuration command,
as described above, the parser writes a linear command
regeneration template 270 to file 271 if the
configuration command segment, beginning with a begin
25 option node and ending with an end option node, is well
behaved. A configuration command segment is well
behaved if:

1. Each branch is unique in a way that each
30 branch causes either a different argument to be
set, or a different value to be set to an
argument; and
2. There cannot be an end command or a sub
mode inside a branch.

35

If a configuration command segment is not well behaved, the prior art method of writing a line for each path through the parse tree is used.

If the configuration command segment is well
5 behaved, linear command regeneration template is generated as described below. TABLE 8 is pseudo code for begin option node template generation during parsing.

10 TABLE 8

```

Beginoption {
    Get the option ID
    Check if this is the first encounter by trying to
15     locate it on the option stack.
    If new
        create item on option stack
        push endoption node to parsing stack
        increment end count
20     print beginoption template mark with all
        necessary details such as number of
        branches, bypass, type, ID, etc.
        push first branch to parsing stack
    else
25     if "generic array"
        count number of time the branch has been
        pushed
        if this number < array count
            push branch to parsing stack
30     else (i.e. the branch has been pushed
        enough times)
            push endoption node to parsing
            stack
            increment end count
35     else

```

```

        find next unpushed branch
        if found
            push this branch to parsing stack
        else (i.e. all branches have been
5         pushed)
            push endoption node to parsing
            stack
            increment end count
    }
10
```

Figure 8 is a process flow diagram 800 for one embodiment of a begin option node template generation presented in TABLE 8. Upon entry to begin option node template generation process 800, get identification operation 810 obtains an option identification that uniquely identifies the offset position of the end option node in the parse tree. Operation 810 transfers to new check operation 820.

In new check operation 820, the option stack is accessed to determine whether the option identification is on the option stack. If the option identification is on the option stack, the begin option node is not new. Conversely, if the option identification is not on the option stack, the begin option node is new. If the begin option node is new, check operation 820 transfers to create item operation 821, and otherwise to array check operation 870.

Create item operation 821 is similar to create item operation 521 (Fig. 5), and that description is incorporated herein by reference. However, in operation 821, the pushing is done as when parameter flags is set to all, irrespective of what the value of parameter flags actually is. Operation 821 transfers to push end option operation 822.

Push end option operation 822 places an end option node on the parsing stack while increment count operation 823 increments an end counter. Increment count operation 823 transfers to write template mark operation 824.

Write template mark operation 824 write a begin option template mark with all the necessary details. For this description, assume that the configuration command is:

TEST AA.

For this example, write template mark operation 824 writes:

TEST {B, S, 2, 0x1, 0}

This template was described above and that description is incorporated herein by reference. Operation 824 transfers to push branch operation 825, which in turn pushes the first branch for configuration command **TEST** on the parsing stack and process 800 is exited through exit 826.

When the parser pops the first branch off the parsing stack, a template for the branch is written to linear command regeneration template 270, which is this example is after this write:

TEST {B, S, 2, 0x1, 0} AA <10, AA>

After the first branch is processed, the next option node template generation method 900 (Fig. 9) is executed.

TABLE 9 is pseudo code for one embodiment of next option node template generation method 900.

TABLE 9

Nextoption {

- 5 Locate current ID on option stack
 Print next option node template mark
 Push corresponding begin option node on parsing
 stack

}

10

In method 900, get ID operation 901 obtains the option ID for the next option node on the option stack, i.e., the current option ID. Get ID operation 901 transfers to write next option node template operation 902.

15

In write next option node template operation 902, a next option node template is written to linear command regeneration template 270 and so after this write, linear command regeneration template 270 is:

20

TEST {B, S, 2, 0x1, 0} AA <10, AA> {N, 0x1}.

Operation 902 transfers to push node operation 903 which in turn pushes the begin option node for the current option ID on the parsing stack, and method 900 is exited.

25

Upon return to method 800, get identification operation 810 obtains an option identification that uniquely identifies the offset position of the end option node in the parse tree. Operation 810 transfers to new check operation 820.

30

In new check operation 820, the option stack is accessed to determine whether the option identification is on the option stack. Since the option

35

identification is on the option stack, check
operation 820 transfers to array check operation 870.

In this example, a generic array is not being used
and so array check operation 807 transfers to unpushed
5 branch check operation 830. However, prior to
considering the action associated with operation 830,
the actions in template generation for a generic array
are described. If parameter flags is set to generic
array, array check operation 870 transfers processing
10 to count operation 871.

Count operation 871 counts the number of times the
branch associated with the begin option node has been
pushed on the parsing stack and transfers to equals
array count check operation 872. If the number of
15 times is less than the array count, i.e., the size of
the array, check operation 872 transfers to push branch
operation 831 that is described below. Conversely if
the number of times is equal to the array count, the
array has been processed and so check operation 872
20 transfers to push end option operation 840 that is
described below.

Returning to the example, and entry to unpushed
branch check operation 830, at this point, the actions
taken depends upon whether there is another branch that
25 has not processed for the begin option node. Since in
the example, there is an additional branch, unpushed
branch check operation 830 finds an unpushed branch and
so transfers to push branch operation 831. Push branch
operation 831 in turn pushes the second branch for
30 configuration command **TEST** on the parsing stack and
process 800 is exited through exit 832.

When the parser pops the second branch off the
parsing stack, a template for the second branch is
written to linear command regeneration template 270,
35 which is in this example after this write:

TEST {B,S,2,0x1,0} AA <10,AA> {N,0x1} BB <10,BB>

After the second branch is processed, the next option
5 node template generation method 900 (Fig. 9) is
executed as described above and so linear command
regeneration template 270 becomes:

10 TEST {B,S,2,0x1,0} AA <10,AA> {N,0x1} BB <10,BB>
 {N,0x1}.

Push node operation 903 again pushes the begin option
node for the current option ID on the parsing stack,
and method 900 is exited.

15 Upon return to method 800, get identification
operation 810 again obtains an option identification
that uniquely identifies the offset position of the end
option node in the parse tree. Operation 810 transfers
to new check operation 820.

20 In new check operation 820, the option stack is
accessed to determine whether the option identification
is on the option stack. Since the option
identification is on the option stack, check
operation 820 transfers through array check
25 operation 870 to unpushed branch check operation 830.

 Since in the example, there are no additional
branches, unpushed branch check operation 830 does not
find an unpushed branch and so transfers to push end
option operation 840.

30 Push end option operation 840 places an end option
node on the parsing stack while increment count
operation 841 increments an end counter. Method 800 is
exited through exit 842.

 When the end option node is popped off the parsing
35 stack, end option node template generation method 1000

(Fig. 10) is executed. TABLE 10 is pseudo code for one embodiment of end option node template generation method 1000.

5 TABLE 10

```

Endoption {
    Locate current ID on option stack
    decrement end count
10    if "generic array"
        reset global argument increment offset to 0
    if end_count > 0
        print endoption template mark
        push next parsing node to parsing stack
15    set ignore bypass
    else
        clean up option stack
}

20    In method 1000, get ID operation 1001 obtains the
    option ID, i.e., the current option ID, from the option
    stack. Get ID operation 1001 transfers to update end
    count operation 1002. In operation 1002, the end count
    is decremented and processing transfers to array check
25    operation 1020.
        If parameter flags is set to generic array, array
        check operation transfers to reset increment offset
        operation 1021 and otherwise to end count check
        operation 1003. In reset increment offset
30    operation 1021 the global argument increment offset is
        set to zero and processing transfers to end count check
        operation 1003.
        If the end count is greater than zero, end count
        check operation 1003 transfers to write end option
35    template operation 1004. Note the end option node is

```

pushed once when the begin option node is processed for the first time, before any branches are processed. After all the branches have been processed, control reverts back to the begin option node, and the end option node is pushed for a second time.

End option template operation 1004 writes an end option node template to linear command regeneration template 270. After this write, linear command regeneration template 270 is:

```
TEST {B,S,2,0x1,0} AA <10,AA> {N,0x1} BB <10,BB>
      {N,0x1} {E,0x1}
```

Operation 1004 transfers to push node operation 1005, which in turn pushes the next parsing node to the parsing stack and transfers to set flag operation 1006. Set flag operation 1006 sets the ignore bypass flag for the begin option node with the current ID, and exits end option node template generation method via exit 1007. However, during template generation processing, the bypass flag is always ignored.

If the end count is zero, end count check operation 1003 transfers to clean-up operation 1010. Clean-up operation 1010 cleans up the option stack, frees memory, and exits end option node template generation method 1000 via exit 1011.

To regenerate a configuration command using linear command regeneration template 270, two functions are used in this embodiment. A first locates the start and end of a linear node, and then passes the linear node to a second function that determines which of the branches in the linear node is valid. Any valid branches are returned to the first function and are pasted into linear command regeneration template 270.

As explained more completely below, for the above example, the two functions process the template string (assuming arg(10) is set to "AA"):

5 TEST {B,S,2,0x1,0} AA <10,AA> {N,0x1} BB <10,BB>
 {N,0x1} {E,0x1}

to yield

10 TEST AA

TABLE 11 is pseudo code for one embodiment of the first function, a filter option function.

15 TABLE 11

Filter_option {

Note: this function scans the template string for begin option node constructs, and passes each of them to

20 Pick_option_path for branch resolution. The call can be recursive if there are nested options.

repeatedly scan for begin option node template, if not found, then exit

extract ID

25 scan template for endoption mark with the ID (not found => error)

cut the option construct (from begin mark to end mark)

pass cut option construct to Pick_option_path()

30 for processing

paste the result from Pick_option_path() back into the template, replacing the cut option construct

}

35

Figure 11 is a process flow diagram for one embodiment of filter option method 1100. In scan template operation 1101, linear command regeneration template 270 is scanned to locate a begin option node
5 template. If a begin option node template is found, begin option check operation 1102 transfers to extract identification operation 1104, and otherwise to exit 1103.

In extract identification operation 1104, the
10 identification in the begin option node is extracted and then scan template operation 1105, scans linear command regeneration template 270 to locate an end option node with the same identification. After locating the end option node, cut node operation 1106
15 cuts the template for the linear node as defined by the begin option node and the end option node from linear command regeneration template 270. The linear node template is passed to the second function, a pick option path method 1200 in call pick path
20 operation 1107. TABLE 12 is pseudo code for one embodiment of pick option path method 1200.

TABLE 12

25 Pick_option_path {
Note: this function looks at each branch of the option construct received as input, and validates / invalidates it depending on:
1. arguments stored in memory / not present
30 and/or
2. values set in arguments match / not match the value on template
If it sees another begin option mark, Filter_option() is called again.
35 initialize return string to null

repeatedly scan for nextoption marks for current ID,
exit when not found
find the beginning and end of current branch
call Filter_option() with this branch string
5 call validate command with the processed string
(find any unsubstituted arguments and/or any
inconsistent set values)
if validated
append processed branch string to return
10 string
if type is "single"
break and exit
else
continue
15 }

In pick option path method 1200, initialize
operation 1201 sets the return string to null and
transfers to find next option node operation 1202. If
20 a next option node with the current identification is
found, processing transfers through next found check
operation 1203 to find branch 1205, and otherwise to
exit 1204.

In find branch 1205, the branch string between the
25 right and left braces of the non-end node templates
with the current identification is extracted. To
determine whether another linear node is embedded
within the current linear node, the branch string is
passed to filter option method 1100 in call filter
30 option operation 1206. If filter option operation 1206
finds an embedded linear node that node is processed.
Otherwise, processing transfers to validate command
operation 467.

In validate command operation 467, the branch
35 string is evaluated with the stored data, and valid

check operation 468 determines whether the branch
string generated the stored data. If the branch string
is validated, valid check operation transfers to append
branch string operation 469, and otherwise to find next
5 option operation 1202.

In append branch string operation 469, the
validated branch string is appended to the return
string, and processing transfers to single type check
operation 470. If the begin option node with the
10 current identification has parameter flags set to
single, check operation 470 transfers to exit
operation 1204, and otherwise to find next option
operation 1202 in which case, operations 1202 to 1206
and 467 to 470 are repeated as appropriate.

15 The novel linear nodes of this invention can be
utilized to represent a wide variety of programming
structures in a linear parse tree, which in turn means
that the linear command regeneration template can be
utilized and so obtain the advantages described above.
20 For example, consider a common programming construct,
an if, then, else control structure of the form
presented in Table 13. This if control structure can
be derived using the linear node structure of this
invention.

25

TABLE 13

if (a)
 then (b)
30 else (c)
 endif

The linear node structure of this invention, in
general, is used to represent an if control structure
35 by:

- a) starting a new begin option node when an if statement is encountered;
- b) using a new then node, as described more completely below, to represent the then statement;
- c) mapping the else statement to two nodes: a next option node, followed by a new else node to start a new branch of the linear node; and
- d) mapping the endif statement to a next option node followed by an end option node.

Figure 13 is a diagram of the linear node structure of this invention for the if control structure of Table 13. Begin option node 1301 in linear node structure 1300 is generated for the if statement. Link list 1310 and matched link list 1311 are equivalent to link list 310 and matched link list 311 that were described above. Parameter flags for begin option node 1301 is set to single. In addition, in this embodiment, begin option node 1301 includes a then flag 1330 that is initialized to a first state, e.g., cleared.

For the if control structure of Table 13, linear node structure 1300 has two branches 1303a and 1303b. Each branch is executed in sequence starting with branch 1303a.

In branch 1303a, operation 1301 tests for "A". If "A" is true, processing transfers to then node 1321 in branch 1303a, and otherwise processing of branch 1303a terminates. If processing transfers to then node 1321, then node 1331 changes the state of then flag 1330 in begin option node 1301, e.g., sets then flag 1330 and transfers to operation 1322 that, in turn, takes action "B" and transfers to next option node 1305a that adds the current branch ID to matched branch list 1311 in

begin option node 1301. Next option node 1305a transfers processing to begin option node 1330, which in turn transfers to end option node 1302.

Note that it is possible that action "B" may not
5 complete successfully, and so next option node 1305a would not be reached. The setting of then flag 1330 assures that branch 1303b, the else branch, is not executed when the test on "A" is true.

When execution of second branch 1303b is started,
10 else node 1325 tests then flag 1330 in begin option node 1301 to determine whether flag 1330 is in the second state. If then flag 1330 is in the second state, processing in branch 1303b terminates. Conversely, if then flag 1330 is in the first state,
15 else node 1325 transfers to operation 1326. Operation 1326 performs action "C" and transfers to next option node 1305b that adds branch 1303b to the matched branch list 1311. Begin option node 1301 transfers processing to end option node 1302.
20 The if, then, else structure of Table 13 is easily extended to include elseif statements as presented, for example, in Table 14.

25 TABLE 14

```

    if (A)
        then (B)
    elseif (C)
30         then (D)
        .
        .
        .
    elseif ((N-1))
35         then (N)
```

```
else ((N+1))  
endif
```

Figure 14 is a diagram of the linear node
5 structure of this invention for the if control
structure of Table 14. Begin option node 1401 in
linear node structure 1400 is generated for the if
statement. Structure 1400 is stored in a memory. Link
list 1410 and matched link list 1411 are equivalent to
10 link list 310 and matched link list 311 that were
described above. Parameter flags for begin option
node 1401 is set to single. In addition, in this
embodiment, begin option node 1401 includes a then
flag 1430 that is initialized to the first state, e.g.,
15 cleared.

For the if control structure of Table 14, linear
node structure 1400 has a plurality of branches 1403_1
to 1403_n. Each branch is executed in sequence
starting with branch 1403_1.

20 In branch 1403_1, operation 1420_1 tests for "A".
If "A" is true, processing transfers to then
node 1421_1 in branch 1403_1, and otherwise processing
of branch 1403_1 terminates. If processing transfers
to then node 1421_1, then node 1421_1 changes the state
25 of the then flag in begin option node 1401, e.g., sets
then flag 1430. Node 1421_1 transfers to
operation 1422_1 that, in turn, takes action "B" and
transfers to next option node 1405_1. Next option
node 1405_1 adds the current branch ID to matched
30 branch list 1411 in begin option node 1401 and
transfers to begin option node 1401, which in turn
transfers to end option node 1402.

When execution of second branch 1403_2 is started,
else node 1425_2 tests then flag 1330 in begin option
35 node 1401 to determine whether flag 1430 is in the

second state. If then flag 1430 is in the second state, processing in branch 1403_2 terminates. Conversely, if then flag 1430 is in the first state, else node 1425_2 transfers to operation 1420_2.

5 Operation 1420_2 tests for "C". If "C" is true, processing transfers to then node 1421_2 in branch 1403_2, and otherwise processing of branch 1403_2 terminates. If processing transfers to then node 1421_2, then node 1421_2 changes the state of
10 the then flag in begin option node 1401, e.g., sets then flag 1430. Then node 1421_2 transfers to operation 1422_2 that, in turn, takes action "D" and transfers to next option node 1405_2 that adds the current branch ID to matched branch list 1411 in begin
15 option node 1401 and transfers to begin option node 1401, which in turn transfers to end option node 1402.

Processing of each branch in turn continues until one branch is satisfied. If processing reaches
20 branch 1403_n, action (n+1) is taken and processing transfers to next node 1405_n, which in turn returns to begin option node 1401.

In the above example only single if control structures were considered. However, since the linear
25 node structure of this invention can be used recursively, if control structures can be included within if control structures, e.g., one or more inner if control structures can be included within an outer if control structure. The processing is the same as
30 that described, except when an inner linear node structure representing an inner if structure completes processing, processing returns to the previous linear node structure representing the previous if control structure.

Figure 15 is a process flow diagram for one embodiment of a then node method 1500. TABLE 15 is pseudo code for one embodiment of then node method 1500.

5

TABLE 15

```

Then_node{
    get the option ID (can't find => error)
10    set then flag to indicate that the then path has
        been taken
    push the then path action into the parsing stack
}

    In method 1500 (Fig. 15), get ID operation 1501
15    obtains the option ID for the then node. This makes
    the option ID the current item on the option stack,
    i.e., the current option ID. Get ID operation 1501
    transfers to ID found check operation 1502.

    If the option ID cannot be found, check
20    operation 1502 transfers to error operation 1503, which
    in turn generates an error message. If the option ID
    is found, found check operation 1502 transfers
    processing to update then flag operation 1504.

    In update then flag operation 1504, the then flag
25    in the begin option node for the current option ID is
    set, and processing transfers to push path 1505. In
    push path operation 1505, the action in the then path
    is pushed on the parsing stack, and method 1500 is
    exited.

30    Figure 16 is a process flow diagram for one
    embodiment of an else node method 1600. TABLE 16 is
    pseudo code for one embodiment of else node
    method 1600.

```

TABLE 16

```

Else_node{
    get the option ID (can't find => error)
5    check then flag to determine if then path has been
        taken
        if then path has not been taken, push the else
            path action into the parsing stack
}
10    In method 1600 (Fig. 16), get ID operation 1601
        obtains the option ID for the else node. This makes
        the option ID the current item on the option stack,
        i.e., the current option ID. Get ID operation 1601
        transfers to ID found check operation 1602.
15    If the option ID cannot be found, check
        operation 1602 transfers to error operation 1603, which
        in turn generates an error message. If the option ID
        is found, found check operation 1602 transfers
        processing to read then flag operation 1604.
20    In read then flag operation 1604, the then flag in
        the begin option node for the current option ID is
        read, and processing transfers to check then flag
        operation 1605. If the then flag is set,
        operation 1605 transfers to end operation 1606 and
25    otherwise to push path operation 1607. In push path
        operation 1607, the action in the else path is pushed
        on the parsing stack, and method 1600 is exited.

        The linear command regeneration template for a
        command that includes an if control structure is the
30    same as that described above. The then and else nodes
        are effectively no-ops, and the node following the then
        or else node is simply pushed on the stack. No special
        processing is required to handle either of these nodes.
        This is clear from Figures 13 and 14, where the paths
35    described above with respect to the linear command

```

regeneration template are the portion of each branch between the begin option node and the next option node.

The embodiments described herein are illustrative only of the principles of the invention and are not
5 intended to limit the invention to the particular embodiments described. In view of this disclosure, those of skill in the art can implement the invention in a wide variety of prior art applications that utilized binary nodes in a parse tree. In addition,
10 the physical device can be other than a network device.

Also, the memory shown in Figures 2A and 2B is typically multiple memory units that include both volatile and non-volatile memories. The memory may include any suitable storage medium for the data files,
15 for example, a hard disk, a floppy disk, a CD-ROM, magnetic tape, flash memory, random access memory, or any other suitable memory.

In more general terms, the methods of this invention are stored in a computer readable medium, and
20 when any one of the methods is loaded from the computer readable medium into a memory of a device, the device is configured to be a special purpose machine that executes the method. This computer readable storage medium may belong to the device itself as illustrated
25 in Figures 2A and 2B, but the storage medium also may be external to the device and may be connected to the device by a data line or a network.

CLAIMS/

I claim:

- 5 1. A method for regenerating a command
comprising:
 storing a linear command regeneration
 template including a linear node template in a
 memory; and
10 reconstructing said command using said linear
 command regeneration template and data from a
 database.
2. The method of Claim 1 wherein said storing a
15 linear command regeneration template further comprises:
 storing a begin option node template in said
 linear node template.
3. The method of Claim 1 wherein said storing a
20 linear command regeneration template further comprises:
 storing a next option node template in said
 linear node template.
4. The method of Claim 1 wherein said storing a
25 linear command regeneration template further comprises:
 storing an end option node template in said
 linear node template.
5. The method of Claim 1 wherein said storing a
30 linear command regeneration template further comprises:
 storing a begin option node template, a next
 option node template, and an end option node
 template in said linear node template.

6. The method of Claim 1 wherein said reconstructing said command using said linear command regeneration template and data from a database further comprises:

5 filtering said linear command regeneration template to locate said linear node template.

7. The method of Claim 6 wherein said filtering said linear command regeneration template to locate
10 said linear node template further comprises:

 scanning said linear command regeneration template to find a begin option node template.

8. The method of Claim 7 wherein said filtering
15 said linear command regeneration template to locate said linear node template further comprises:

 obtaining an identification of said begin option node template.

9. The method of Claim 8 wherein said filtering
20 said linear command regeneration template to locate said linear node template further comprises:

 scanning said linear command regeneration template to find an end option node template
25 including said identification.

10. The method of Claim 6 further comprising:
 passing said linear node template from said linear command regeneration template to an
30 evaluate branches process.

11. The method of Claim 10 further comprising:
 evaluating at least one branch in said linear node template from said linear command

regeneration template by said evaluate branches process.

12. The method of Claim 10 wherein said
5 evaluating at least one branch in said linear node from said linear command regeneration template further comprises:

finding a branch in said linear node
template.

10

13. The method of Claim 10 wherein said
evaluating at least one branch in said linear node from said linear command regeneration template further
comprises:

15 validating said branch using said data from said database.

14. A memory storing a method for regenerating a
20 command, said method comprising:

storing a linear command regeneration
template including a linear node template in a
memory; and

25 reconstructing said command using said linear command regeneration template and data from a database.

15. The memory of Claim 14 wherein said storing a
linear command regeneration template further comprises:

30 storing a begin option node template in said linear node template.

16. The memory of Claim 14 wherein said storing a linear command regeneration template further comprises:

storing a next option node template in said linear node template.

17. The memory of Claim 14 wherein said storing a linear command regeneration template further comprises:
5 storing an end option node template in said linear node template.

18. The memory of Claim 14 wherein said storing a linear command regeneration template further comprises:
10 storing a begin option node template, a next option node template, and an end option node template in said linear node template.

19. The memory of Claim 14 wherein said reconstructing said command using said linear command regeneration template and data from a database further comprises:
15

filtering said linear command regeneration template to locate said linear node template.
20

20. The memory of Claim 19 wherein said filtering said linear command regeneration template to locate said linear node template further comprises:
25

scanning said linear command regeneration template to find a begin option node template.

21. The memory of Claim 20 wherein said filtering said linear command regeneration template to locate said linear node template further comprises:
30

obtaining an identification of said begin option node template.

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22. The memory of Claim 21 wherein said filtering
said linear command regeneration template to locate
said linear node template further comprises:

5 scanning said linear command regeneration
template to find an end option node template
including said identification.

23. The memory of Claim 19 further comprising:
10 passing said linear node template from said
linear command regeneration template to an
evaluate branches process.

24. The memory of Claim 23 further comprising:
15 evaluating at least one branch in said linear
node template from said linear command
regeneration template by said evaluate branches
process.

25. The memory of Claim 24 wherein said
20 evaluating at least one branch in said linear node from
said linear command regeneration template further
comprises:

25 finding a branch in said linear node
template.

26. The memory of Claim 25 wherein said
evaluating at least one branch in said linear node from
said linear command regeneration template further
comprises:

30 validating said branch using said data from
said database.

27. A network device comprising:
a processor; and

a memory coupled to said processor, and
storing a method for regenerating a command
wherein upon execution of said method by said
processor, said method comprises:

- 5 storing a linear command regeneration
template including a linear node template in said
memory; and
 reconstructing said command using said linear
command regeneration template and data from a
10 database.

28. The network device of Claim 27 wherein said
storing a linear command regeneration template further
comprises:

- 15 storing a begin option node template in said
linear node template.

29. The network device of Claim 27 wherein said
storing a linear command regeneration template further
20 comprises:

- storing a next option node template in said
linear node template.

30. The network device of Claim 27 wherein said
25 storing a linear command regeneration template further
comprises:

- storing an end option node template in said
linear node template.

31. The network device of Claim 27 wherein said
30 storing a linear command regeneration template further
comprises:

- storing a begin option node template, a next
option node template, and an end option node
35 template in said linear node template.

32. The network device of Claim 27 wherein said
reconstructing said command using said linear command
regeneration template and data from a database further
5 comprises:

filtering said linear command regeneration
template to locate said linear node template.

33. The network device of Claim 32 wherein said
10 filtering said linear command regeneration template to
locate said linear node template further comprises:

scanning said linear command regeneration
template to find a begin option node template.

34. The network device of Claim 33 wherein said
15 filtering said linear command regeneration template to
locate said linear node template further comprises:

obtaining an identification of said begin
option node template.

35. The network device of Claim 34 wherein said
20 filtering said linear command regeneration template to
locate said linear node template further comprises:

scanning said linear command regeneration
25 template to find an end option node template
including said identification.

36. The network device of Claim 32 further
comprising:

30 passing said linear node template from said
linear command regeneration template to an
evaluate branches process.

37. The network device of Claim 36 further
35 comprising:

evaluating at least one branch in said linear node template from said linear command regeneration template by said evaluate branches process.

5

38. The network device of Claim 36 wherein said evaluating at least one branch in said linear node from said linear command regeneration template further comprises:

10 finding a branch in said linear node template.

39. The network device of Claim 36 wherein said evaluating at least one branch in said linear node from said linear command regeneration template further comprises:

validating said branch using said data from said database.

20 40. A structure for regenerating a command comprising:

means for storing a linear command regeneration template including a linear node template in a memory; and

25 means for reconstructing said command using said linear command regeneration template and data from a database.

41. The structure of Claim 40 wherein said means for storing a linear command regeneration template further comprises:

means for storing a begin option node template in said linear node template.

42. The structure of Claim 41 wherein said means for storing a linear command regeneration template further comprises:

5 means for storing a next option node template in said linear node template.

43. The structure of Claim 40 wherein said means for storing a linear command regeneration template further comprises:

10 means for storing an end option node template in said linear node template.

44. The structure of Claim 40 wherein said means for storing a linear command regeneration template further comprises:

15 means for storing a begin option node template, a next option node template, and an end option node template in said linear node template.

20 45. The structure of Claim 40 wherein said means for reconstructing said command using said linear command regeneration template and data from a database further comprises:

25 means for filtering said linear command regeneration template to locate said linear node template.

46. The structure of Claim 45 wherein said means for filtering said linear command regeneration template to locate said linear node template further comprises:

30 means for scanning said linear command regeneration template to find a begin option node template.

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Method and Apparatus for Scalable Handling of Non-Tree
Structures In Parser Tree Reconstruction

Fan Kong

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ABSTRACT OF THE DISCLOSURE

10 A linear node includes a begin option node that
has a direct link to an end option node. The begin
option node has a single entry, and also includes a
list of links with each entry in the list being a link
to one of a plurality of parallel branches. Each of
the plurality of branches represents one possible value
of a command element of the configuration command.
15 Each branch is connected back to the begin option node
through a next option node. During parsing of a
command, each command element is represented by a
different linear node. Also, during parsing of the
command, a linear command regeneration template is
20 generated that includes a begin option node template, a
next option node template, and an end option node
template. The linear command regeneration template is
used to recreate the original command using data in a
system configuration database.

25

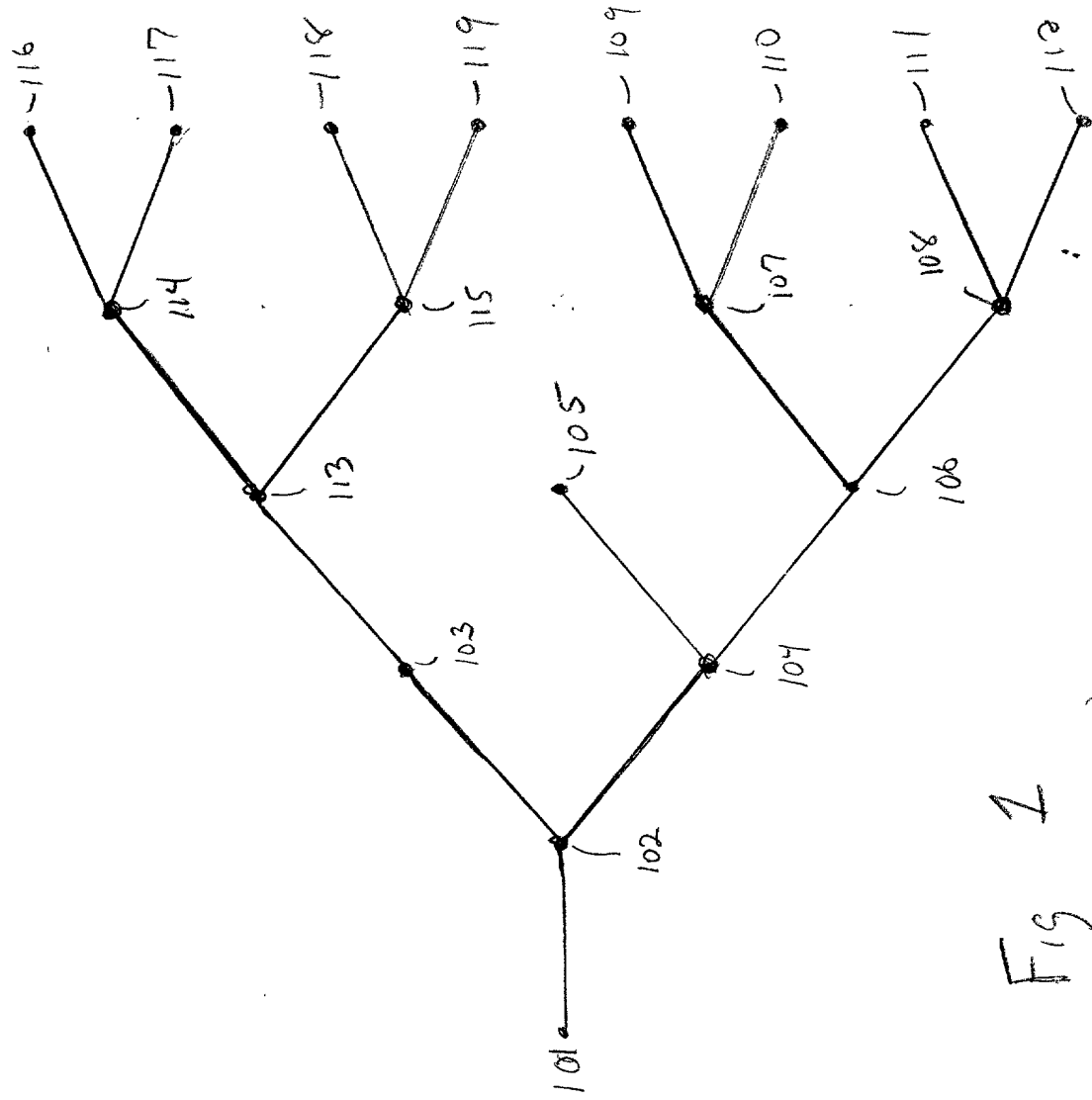
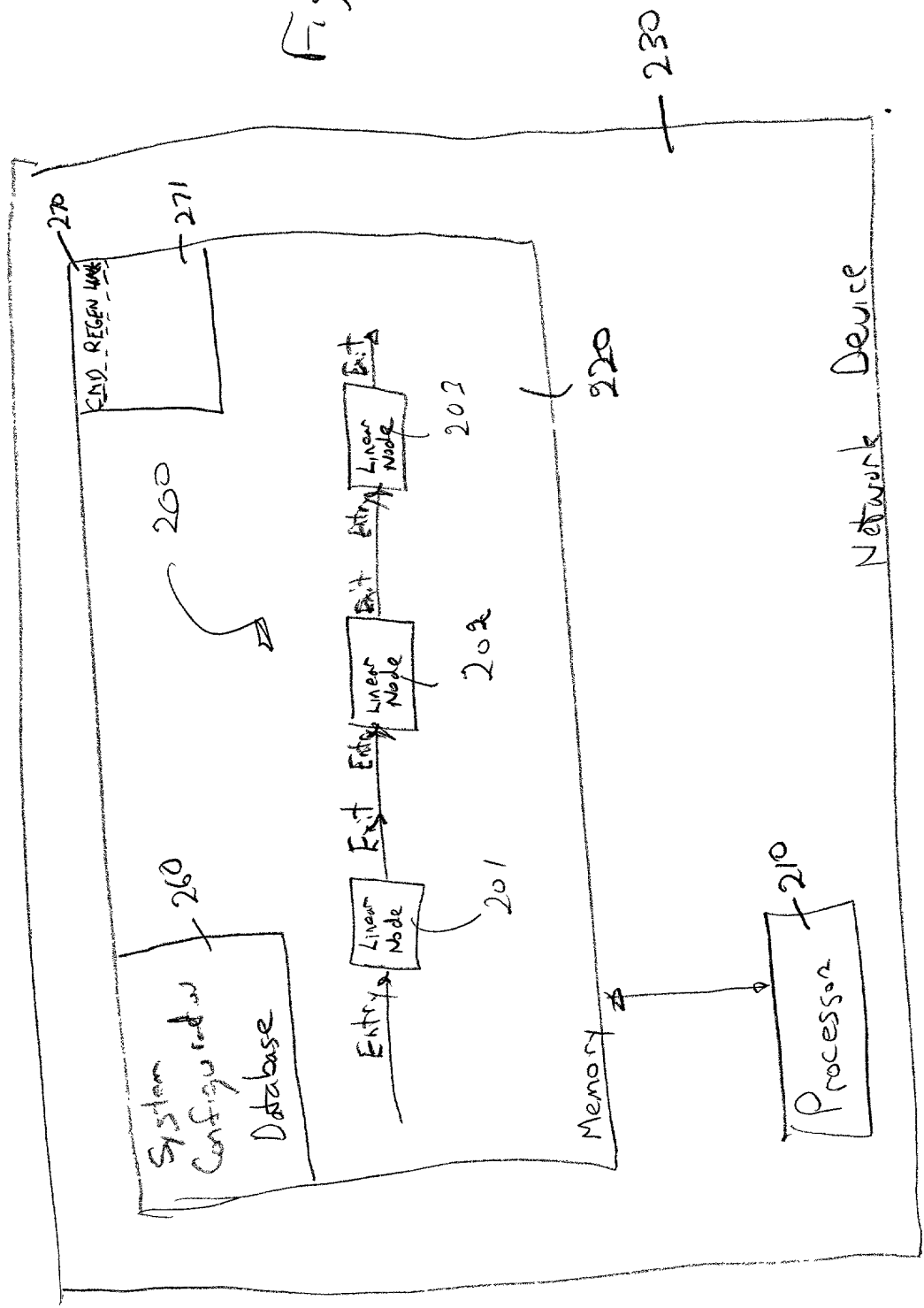


Fig 1
(Prior Art)

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Fig 2A



230



Network Device

Processor

2

Memory

2

202

203

5

4-257

4/20

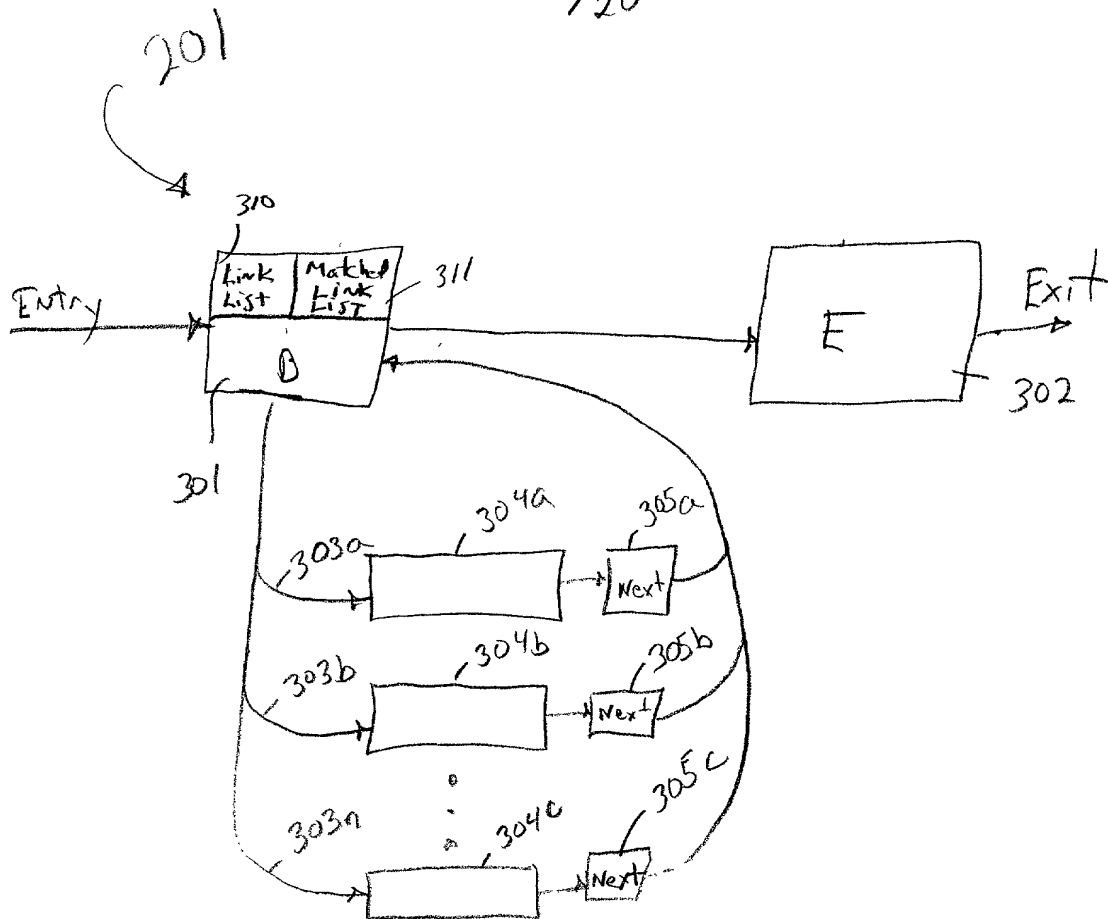


Fig. 3

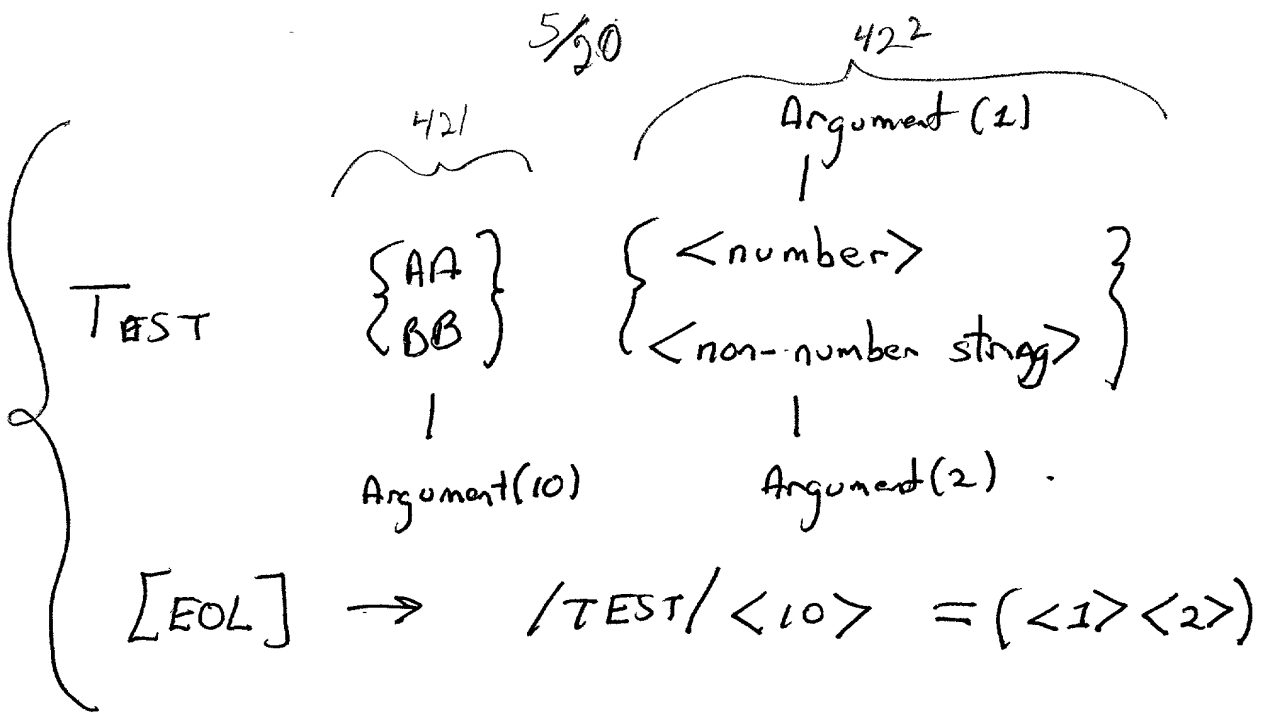
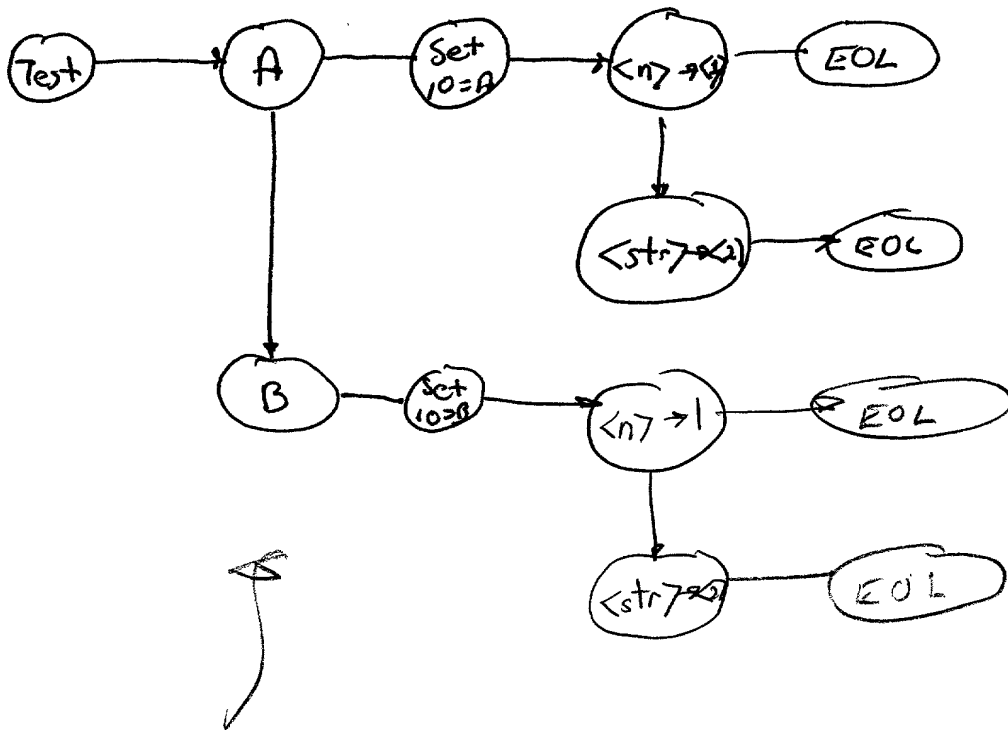


Fig. 4A
(Prior ART)



4/00

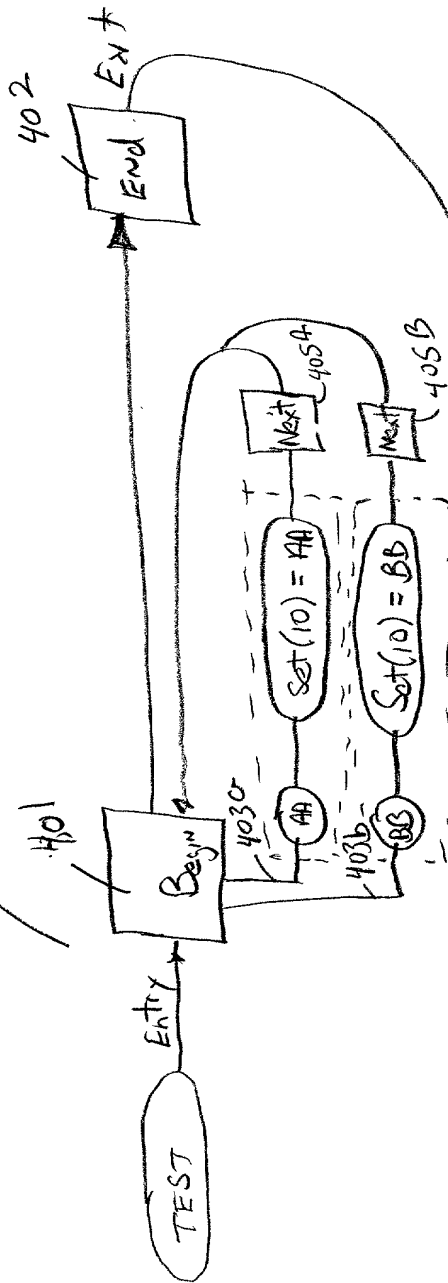
Fig. 4B
(Prior ART)

6/20

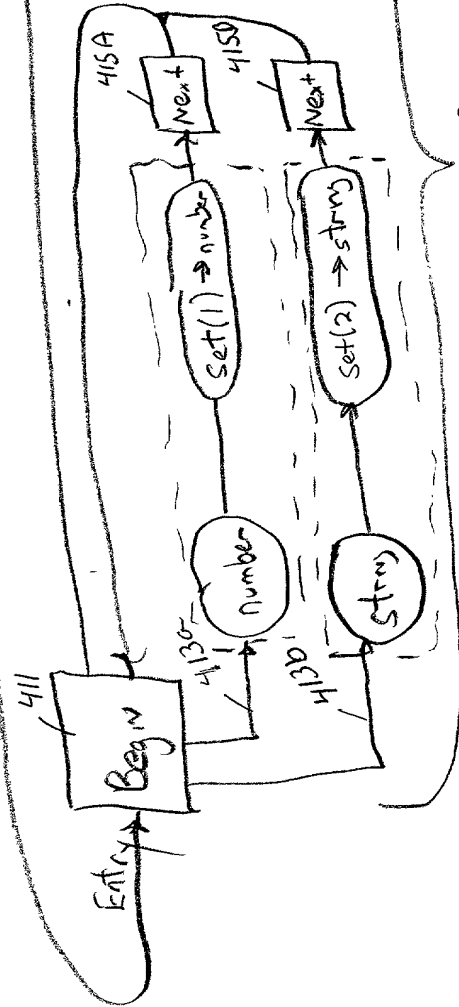
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TEST	A	$[SET(10) = A]$	$[<string> \rightarrow \times 22]$
TEST	B	$[SET(10) = B]$	$[<n> \rightarrow \times 12]$
TEST	B	$[SET(10) = B]$	$[<string> \rightarrow \times 22]$

Fig. 4C
(Prior Art)

451

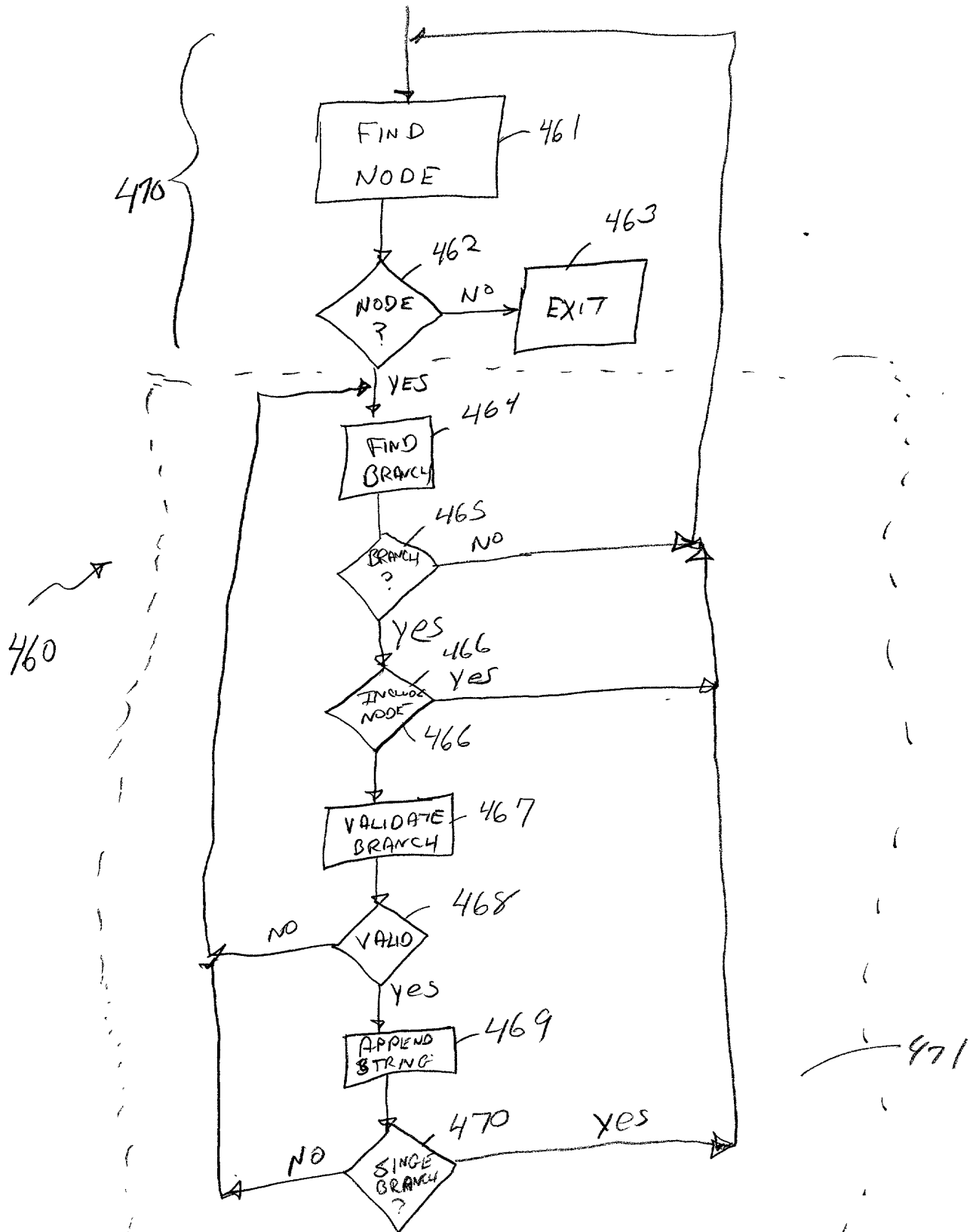


450



452

Fig 40



EVALUATE BRANCHES - Fig. 4E

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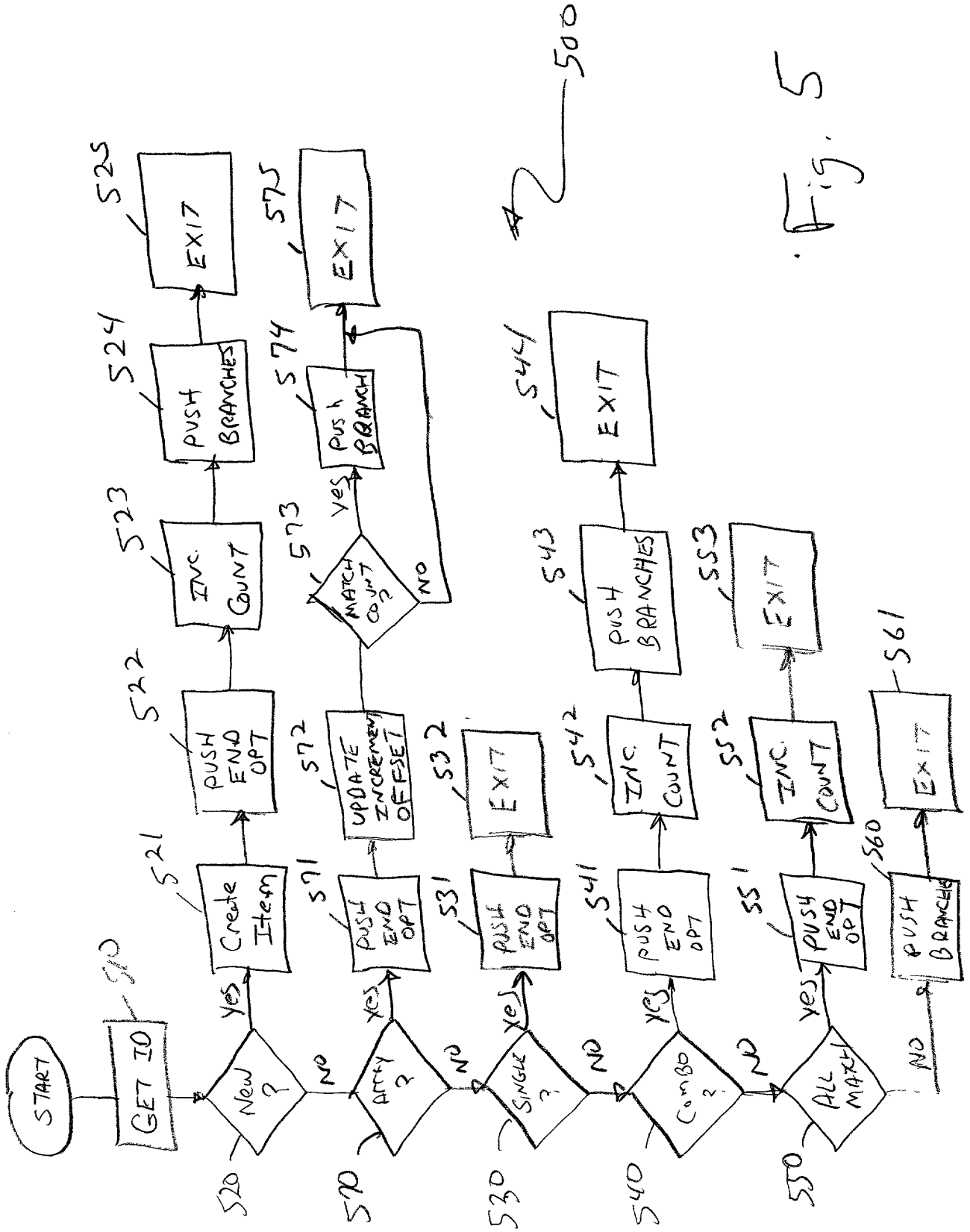


Fig. 5

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600
A

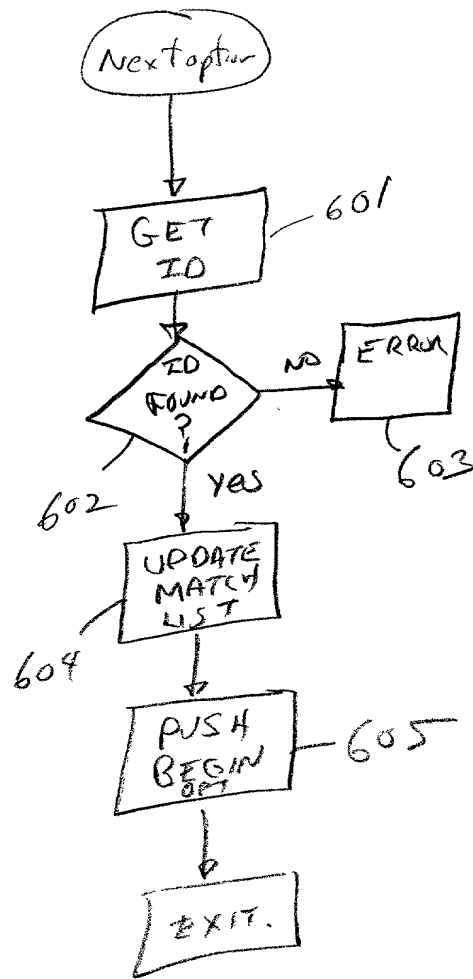


Fig 6

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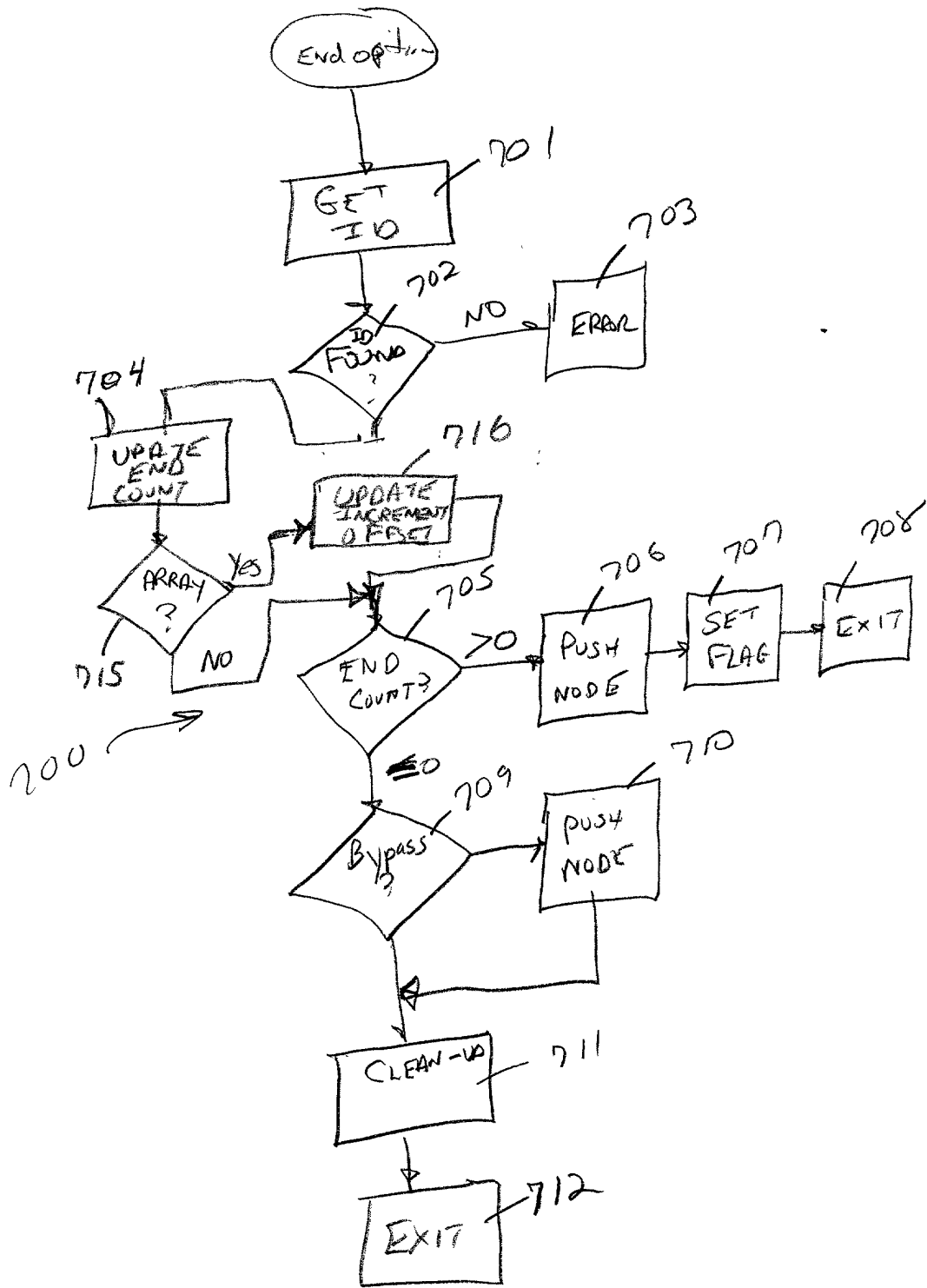


Fig. 7

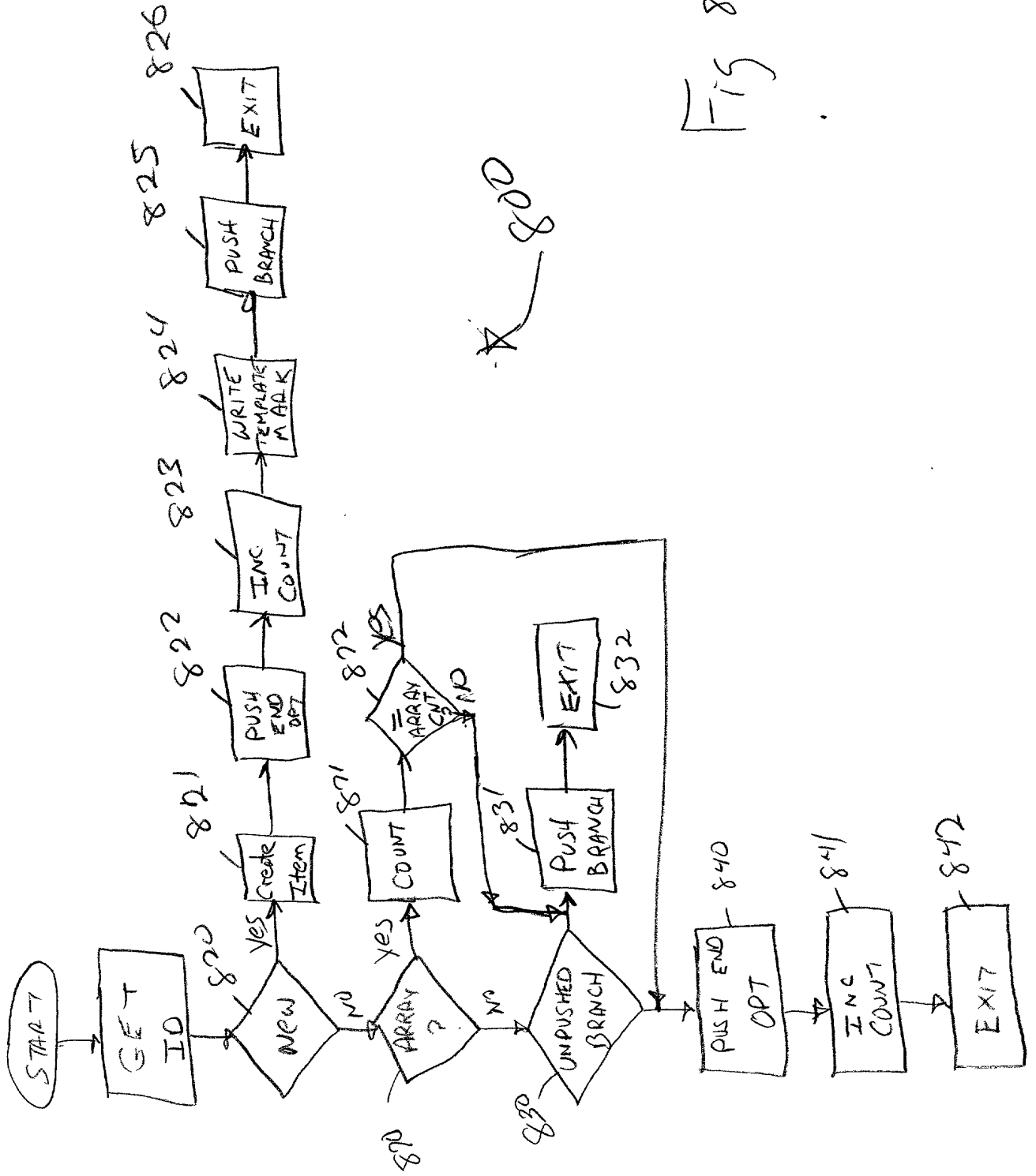


Fig 8

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900

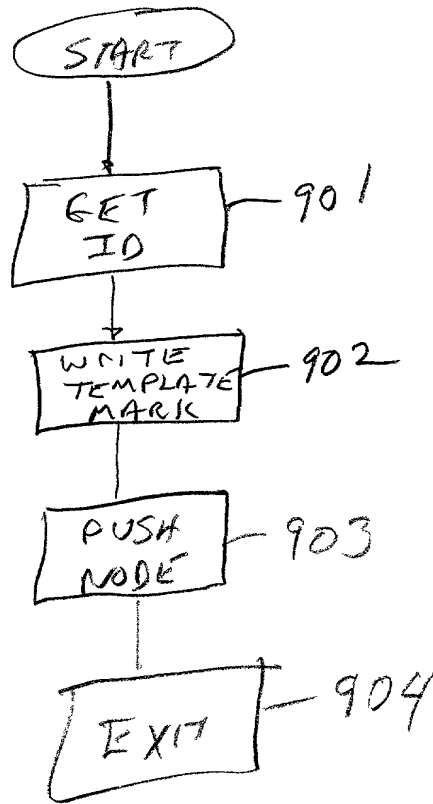


Fig. 9.

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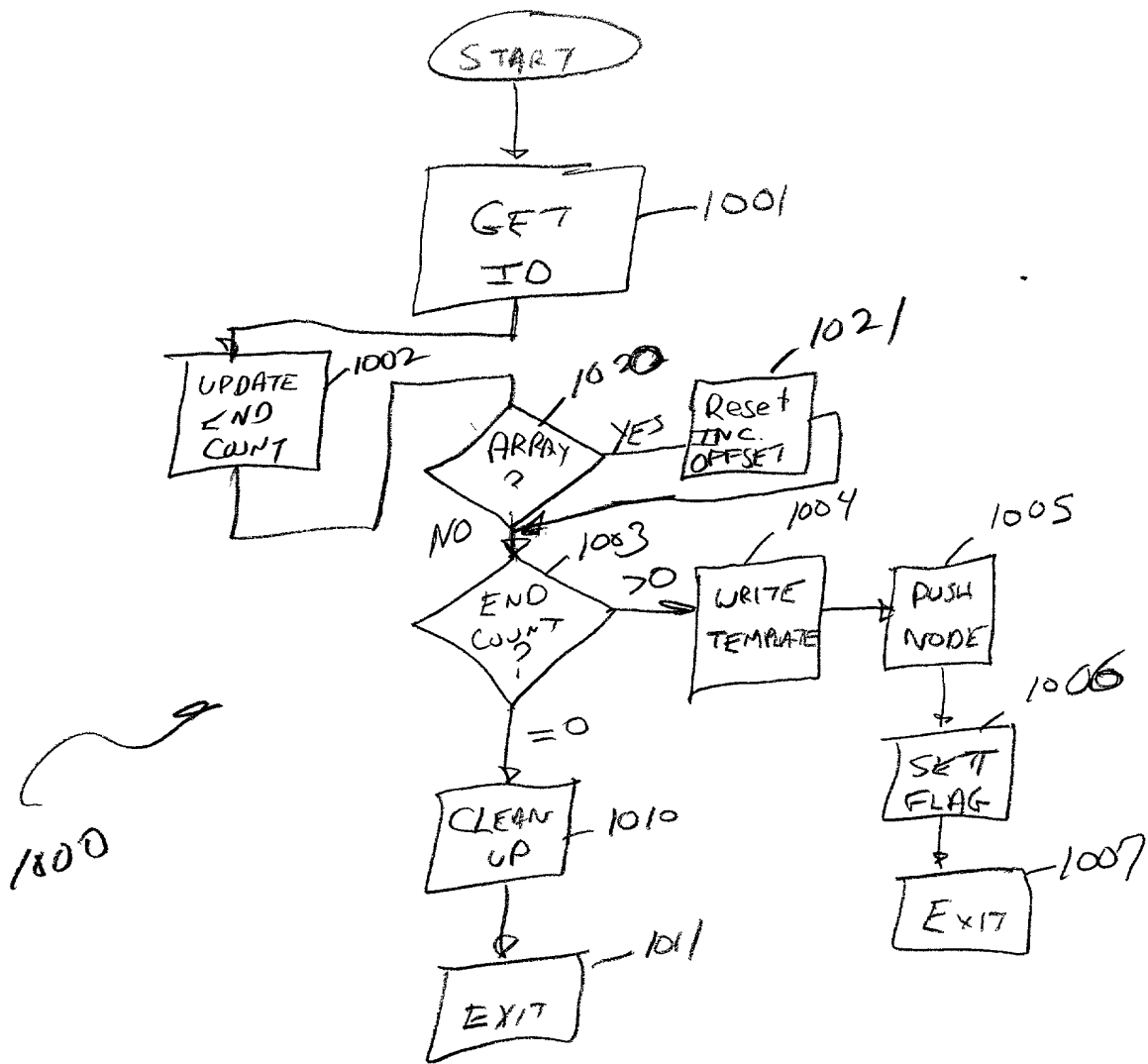


Fig. 10

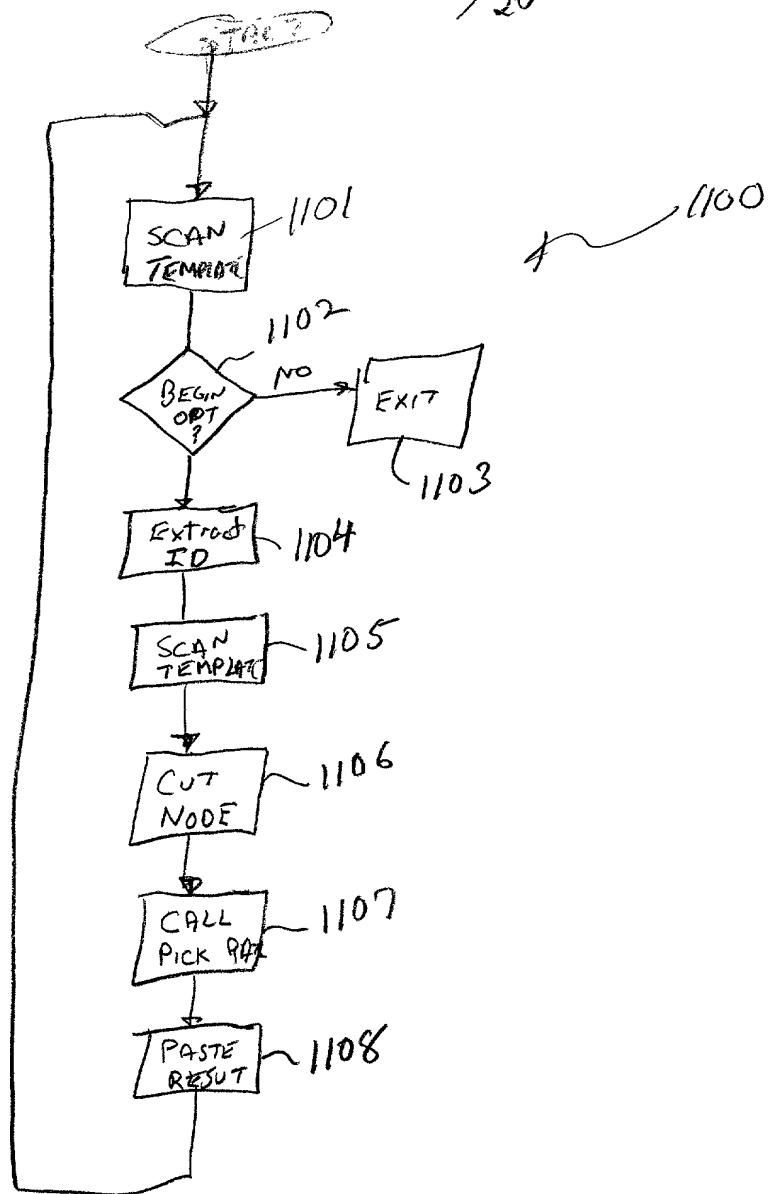


Fig. 11

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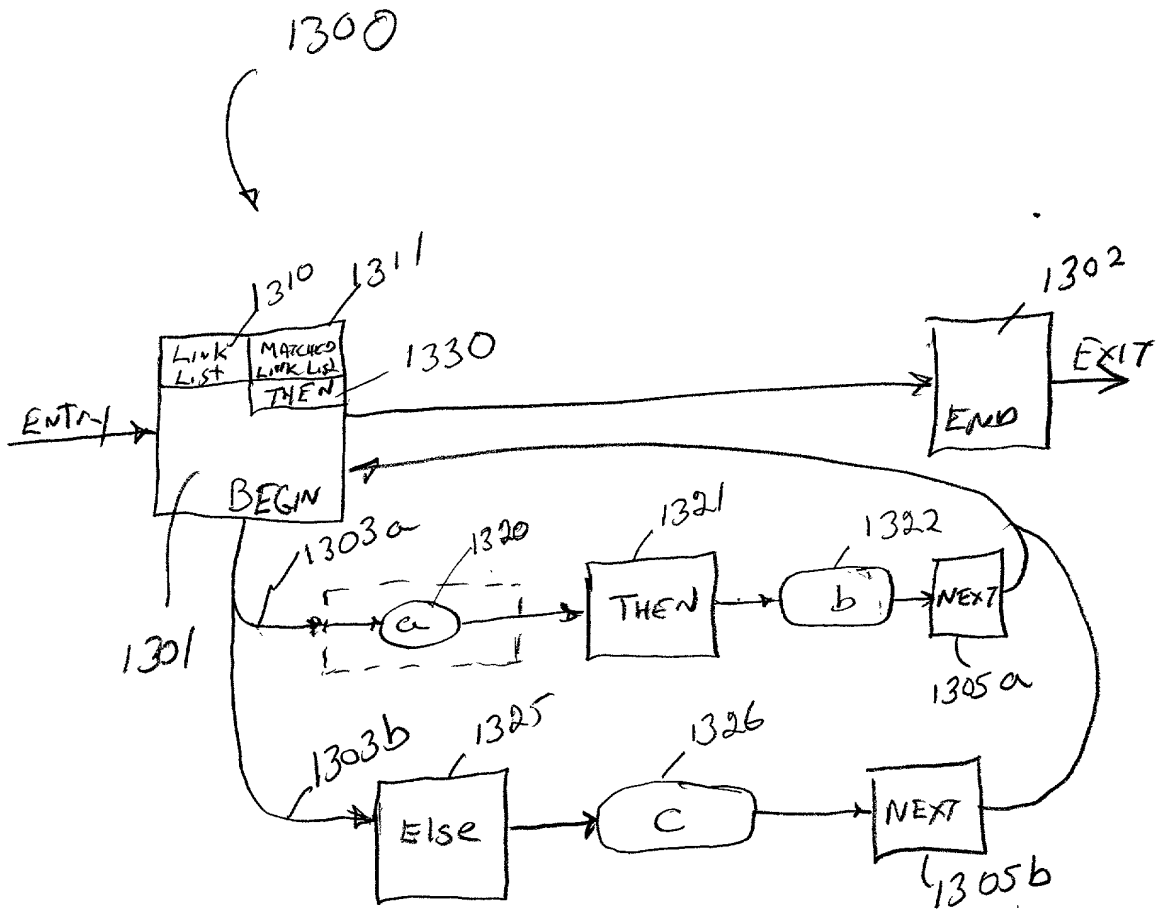
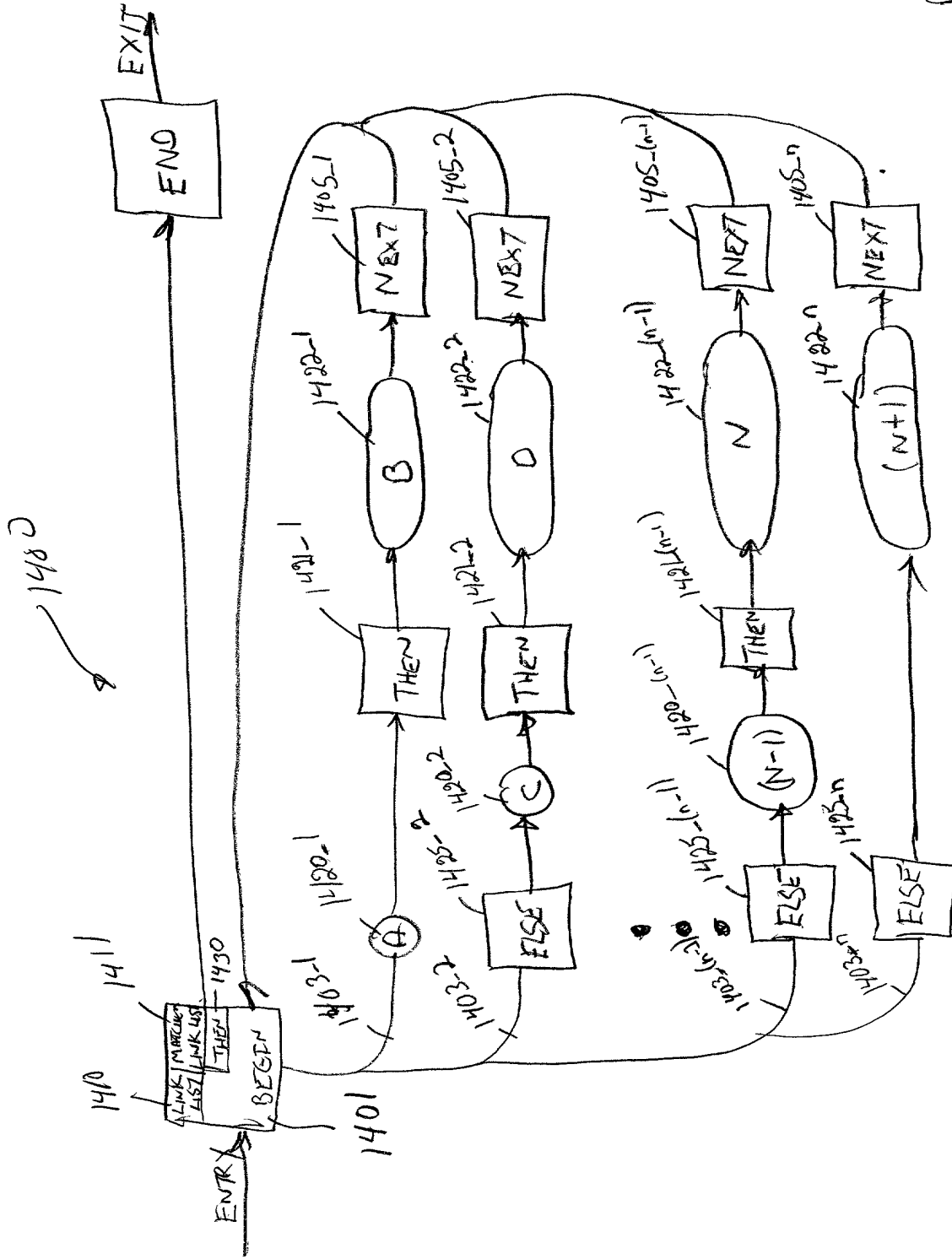


Fig 13



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1500 ↗

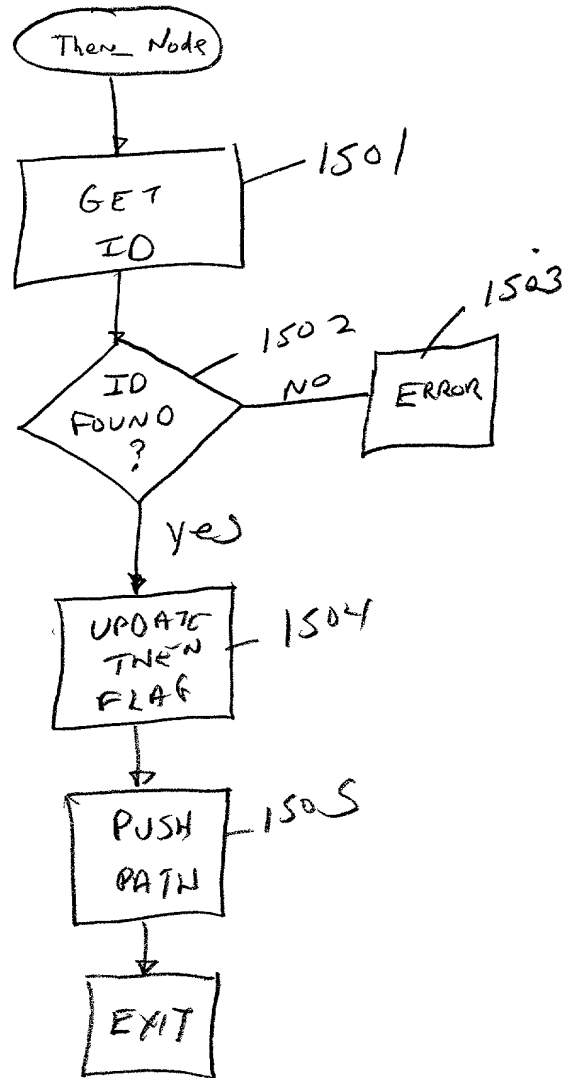


Fig. 15

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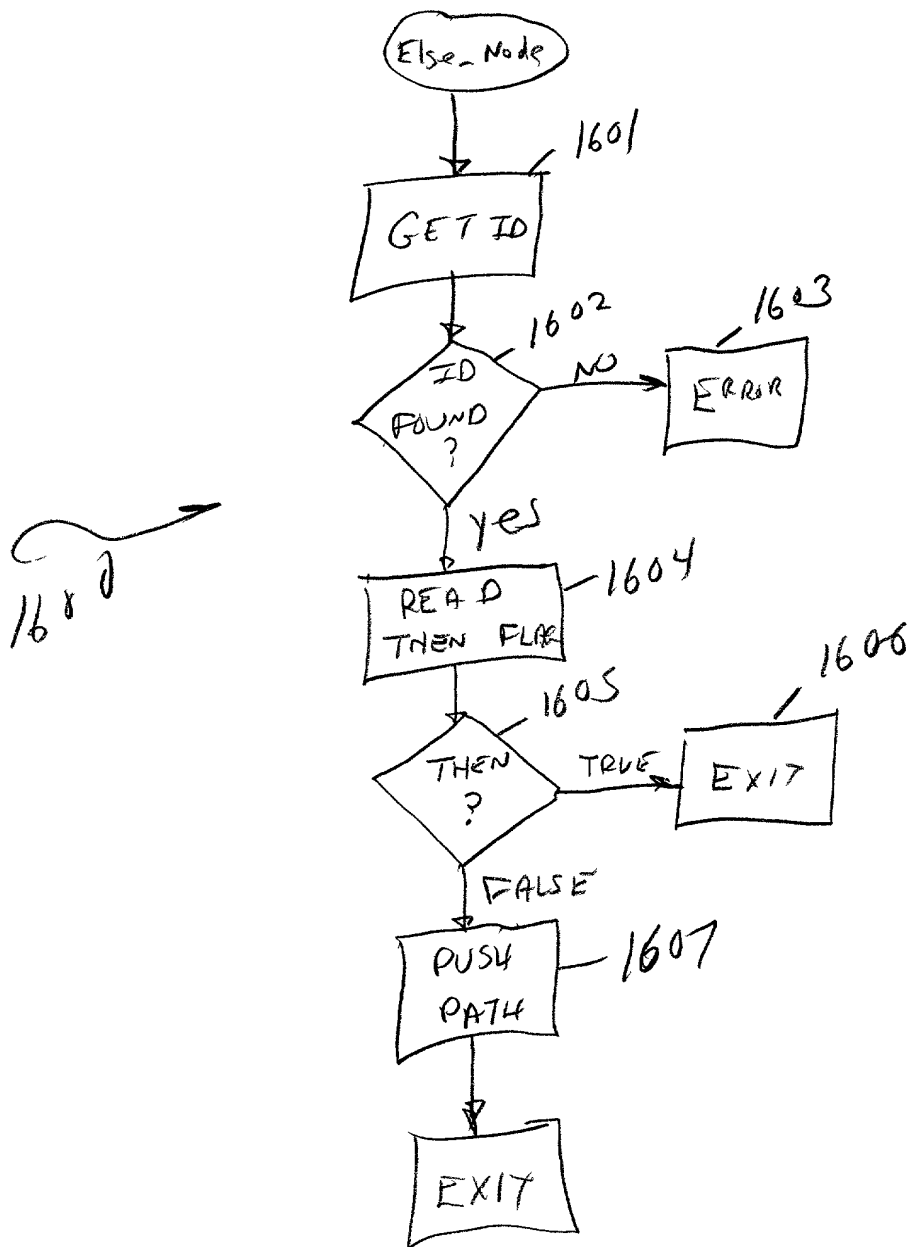


Fig. 16

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

NA		
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)

NA		
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)

NA		
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)

I hereby appoint the attorney(s) and/or agent(s) assigned to the Customer Number below to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith:

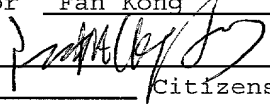
Customer Number 23513

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Facsimile: 831-655-0888

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor Fan Kong
Inventor's signature  Date 10/12/2000
Residence Cupertino, CA 95014 Citizenship China (Hong Kong)
Post Office Address 10537 Johnson Ave.
Cupertino, CA 95014

COMBINED DECLARATION FOR PATENT APPLICATION
AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of subject matter (process, machine, manufacture, or composition of matter, or an improvement thereof) which is claimed and for which a patent is sought by way of the application entitled "Method and Apparatus for Scalable Handling of Non-Tree Structures in Parser Tree Reconstruction" which

- [x] is attached hereto.
[] and is amended by the Preliminary Amendment attached hereto.
[] was filed on _____
as Application Serial No. _____
[] and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the specification, including the claims of the application entitled "Method and Apparatus for Scalable Handling of Non-Tree Structures in Parser Tree Reconstruction", as amended by any amendment referred to above.

I acknowledge the duty to disclose information known to me which is material to patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Claimed
NA			[] Yes [] No
(Number)	(Country)	(Day/Month/Year Filed)	
NA			[] Yes [] No
(Number)	(Country)	(Day/Month/Year Filed)	
NA			[] Yes [] No
(Number)	(Country)	(Day/Month/Year Filed)	